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VOLUME V
Number 8

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THE EXAMINATION OF AVIATORS
LIGHT ALLOYS IN AIRCRAFT CONSTRUCTION
NATIONAL PHYSICAL LABORATORY REPORT

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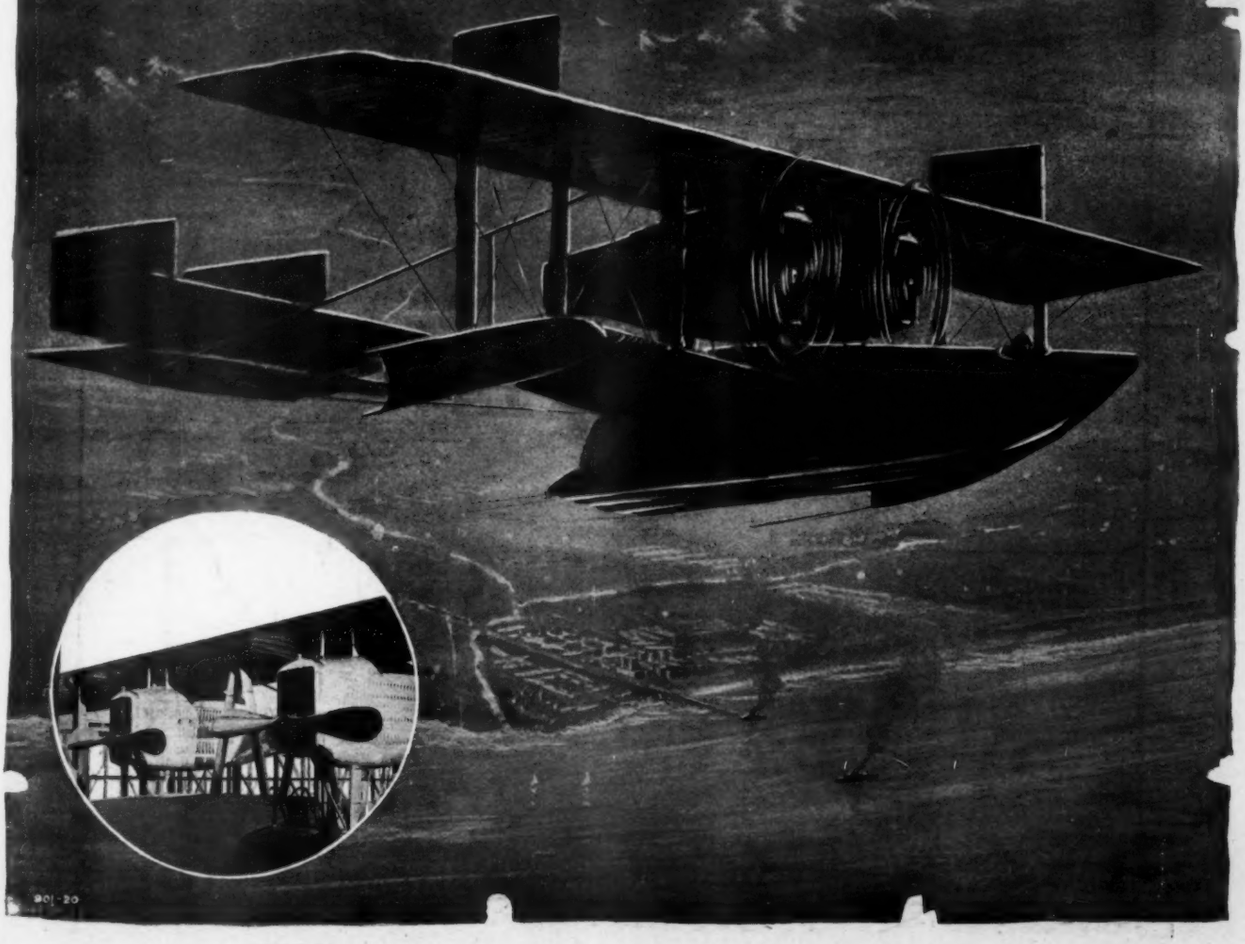

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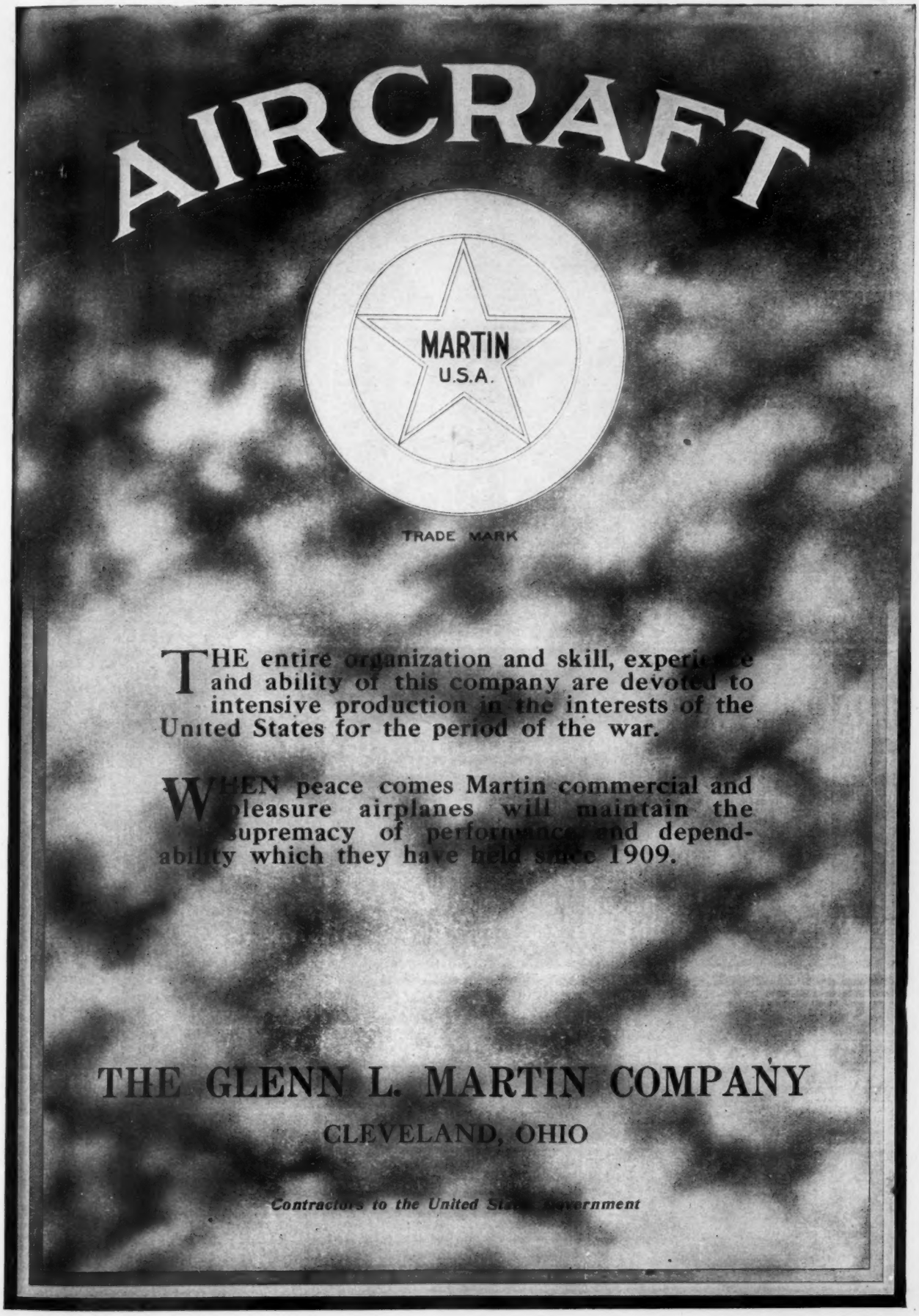
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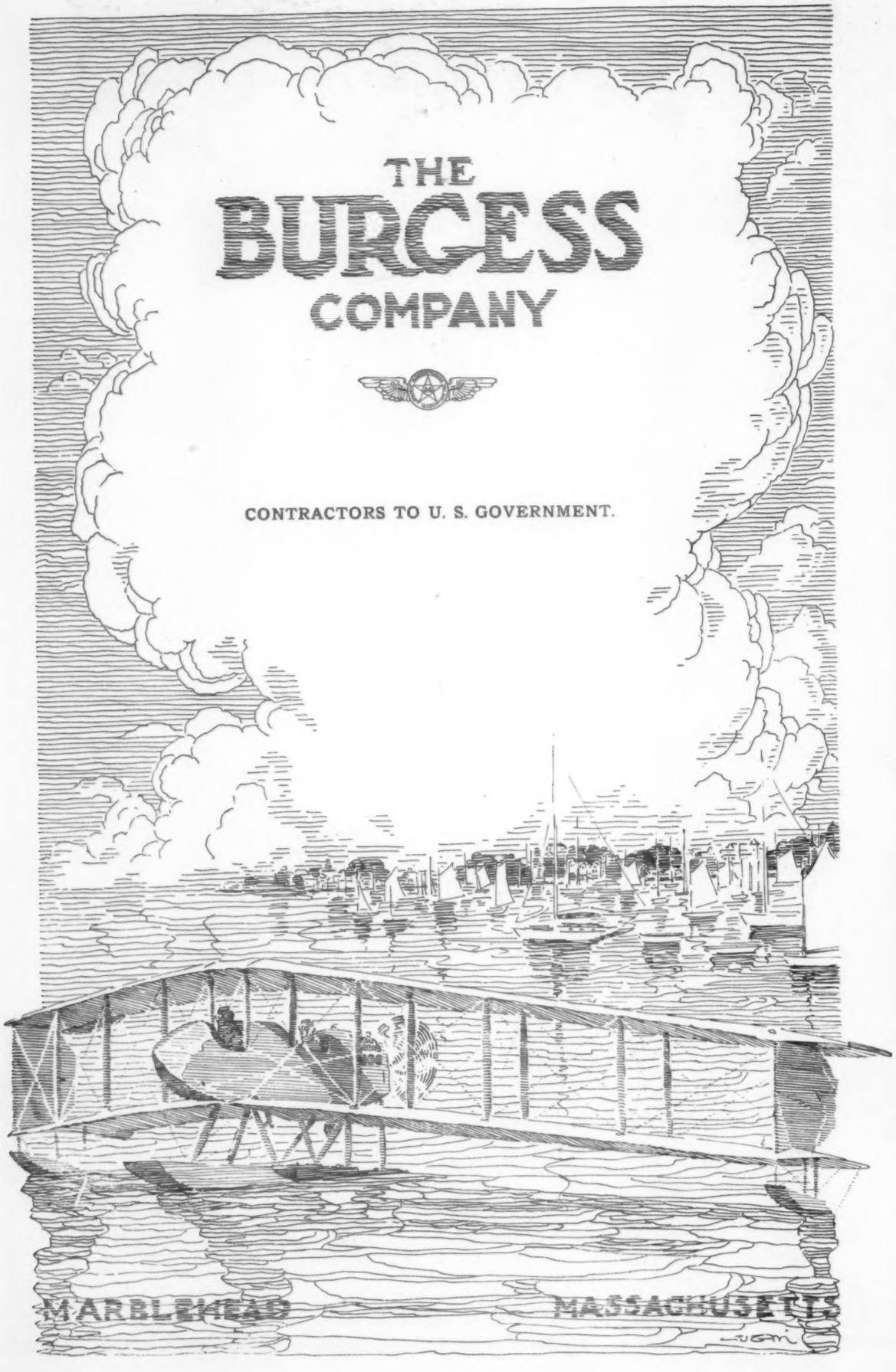
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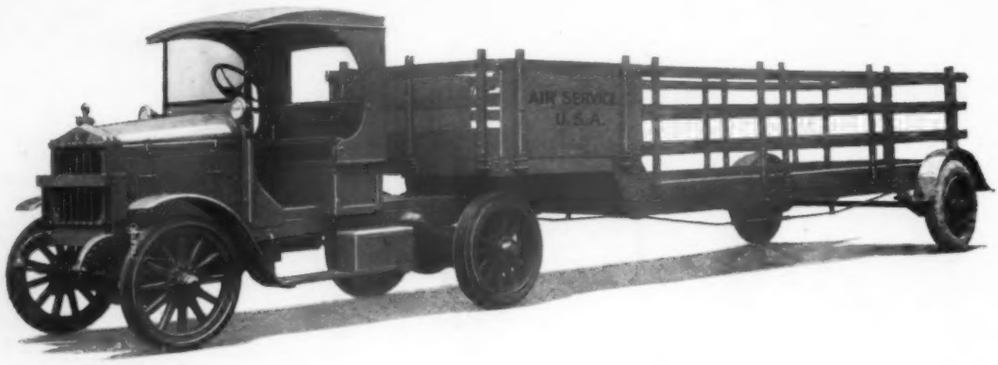

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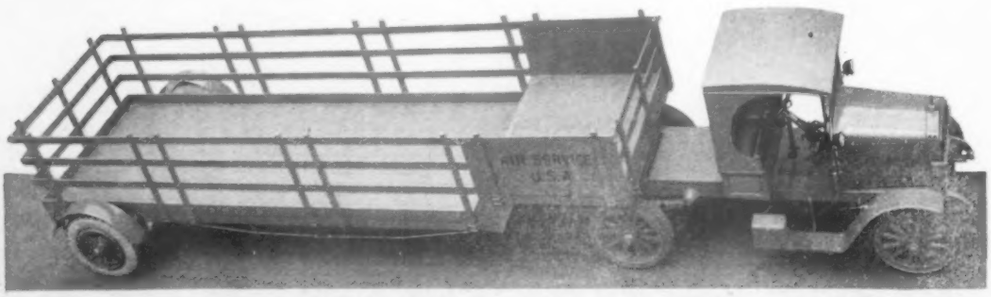

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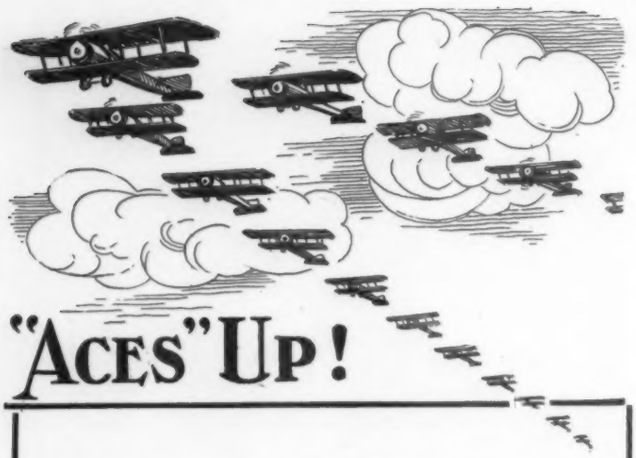

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AVIATION AND AERONAUTICAL ENGINEERING

VOL. V. NO. 8

Member of the Audit Bureau of Circulations

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Dopes, Doping and Ventilation

By Frank A. Leedy

Inspector. Aircraft Production Division (Detroit District)

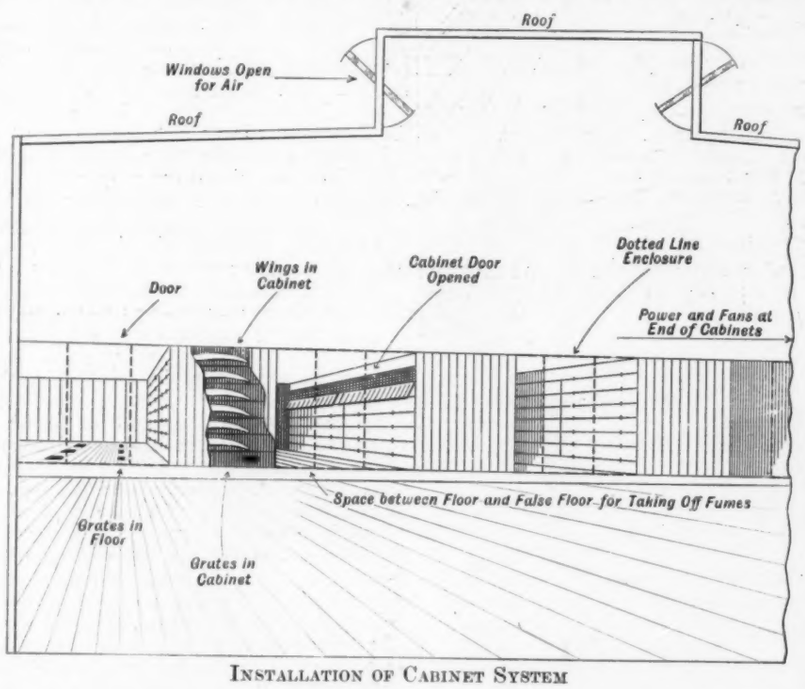
Dope is a soluble cellulose, either a nitrate or an acetate, which is also known as pyroxelyne varnish, collodion, lacquer, etc. The solvents are of the various alcohols, ketones, benzol and gasoline, and are usually held in suspension or mixture by certain proportions which are easily separated and thrown out; therefore it is unwise for dopers to interfere by adding to, or changing, mixtures. Where it is necessary to use thinners it is much safer to have the respective manufacturer furnish same. The nitrate dope is very good, but inflammable; it is therefore used only on training planes and must be covered with an enamel or spar varnish, to prevent or retard burning. The acetate dope is the more widely used and in preference solely for the reason that it is not inflammable. This dope is the result of recent discoveries and is made by treating cellulose with acetic anhydrid in the presence of sulphuric acid or zinc chloride through a heat process.

The solvents are prepared with a high and a low boiling point. The former have the object to retard evaporation, which helps to prevent blushing (turning white), but also retard shrinking, which is not desirable; they are, therefore, used sparingly. The latter solvents are much stronger in their cutting or dissolving properties and increase shrinking. In the acetate dope, diacetone alcohol is used for the high boiler, and methyl acetate and methyl (acetone) is used for the lower.

Until recently tetrachlorethane was used as a high boiler, but owing to its deleterious fumes and toxic effect on the human system it had to be discarded, which was made possible thanks to the chemists who have succeeded in furnishing its substitute. The nitrate dope also has a high and low boiler, the former being either amyl acetate or butyl acetate, and the latter is the alcohols, acetone, benzol and gasoline. There is not much difference in the appearance and working of the two dopes; in fact, very few dopers are able to distinguish one from the other.

Dopes do not dry or solidify by oxidation as paints and oil varnishes do. They are what are termed spirit varnishes, and on evaporation of the solvents a transparent, coherent and elastic film is deposited.

The dopes are used as a coating on fabric covered surfaces for the purpose of making them taut by shrinking, as well as a filler and protection to the fabric. The dope is applied with short, stubby brushes, and is handled somewhat like oil varnish, only it is necessary to lay off the work as you go, for it sets very quickly, and, on setting, it does not pull as an oil varnish, but rolls and breaks, and becomes unmanageable. It is much better to dope surfaces lying flat and not vertical, as some do, as the dope cannot be flowed as an oil varnish, nor brushed out as an oil paint. The first coat is the most important, and should be well brushed into the fabric so as to adhere and prevent peeling.



INSTALLATION OF CABINET SYSTEM

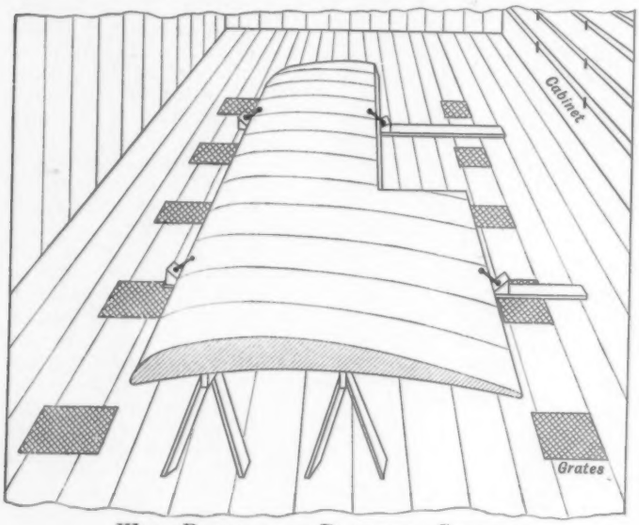
The greatest difficulty in handling dope is to prevent "blushing." This is caused by the quick evaporation of the solvents whereby the air temperature is reduced, near the surface, below dew point, and the resulting condensation deposits water on the film. This causes it to turn white and reduces its tensile strength, which should not be allowed, although a great deal of blushing is covered over with the finishing enamel and hides all evidence. To properly prevent blushing it is necessary to keep the relative humidity of drying-room below 50 deg. Fahr. This can be done by merely heating the room sufficiently, although it would be necessary to run the temperature to 105 deg. Fahr. and over, at times depending upon the natural conditions of weather. Of course, this temperature would be very hard on the workers, and for this and other reasons the writer recommends cabinets for drying the surfaces, as will be explained later. Suppose the air temperature is 90 deg. Fahr., with the wet bulb at 85 deg. Fahr.—a common condition in the summer months—then in order to condition this proportion and reduce the relative humidity to 50, it would be necessary to run the temperature up to 102 deg., which would not be a very pleasant temperature to work in.

Now, there is another way to overcome this, and that is to use a cooling system in connection with the heating system. There are several cooling systems on the market which are known as the washed-air system. The air is simply cooled by being forced through sprays of water. With this system the same natural air condition could be handled by cooling the air

to 75 deg. Fahr., for it would condense and force enough moisture out of the air that, when delivered to the working room and heated back to 90 deg., there would be a relative humidity of 50. This system would be very satisfactory, but is very expensive on account of the amount of air it requires for supplying the ventilation system.

This essential system is quite a problem, and the writer has seen many mistakes made by those who did not understand it, or handled it lightly. In the first place, a down-draft system is best for the reason that the fumes from the solvents are slightly heavier than air and have a tendency to settle; as the surfaces are laying on trestles while being coated they are below breathing elevation, which is quite an advantage in using the down-draft system.

This system should be operated by suction only and the air should be brought down slowly in a large volume, and not with velocity. The draft should not be noticeable, as this would accelerate the evaporation of the solvents and promote blushing. In order to get these results, 2 by 2 ft. grates should be placed 6 ft. apart on the floor, and a motor and fan be used with sufficient capacity to displace 30 changes of air per hour, figuring from good head level to floor. Of course, it would be



WING READY TO BE PLACED IN CABINET

necessary to keep all doors and windows shut to prevent any drafts that would agitate and cause the fume-laden air to ascend. Besides, there should be openings high above to admit large volumes of air.

The best method of arrangement for doping is, in the writer's opinion, the cabinet system he originated, and which is being used on the Pacific Coast by more than one manufacturer. The cabinet system is not patented, and it is only the pride and interest that the writer takes in what he considers his own success that prompts him to recommend same.

Considering the smaller volume of air to heat and displace, besides the better working conditions it insures to the dopers, and the dependable production at all weather conditions, this system is by far the cheapest.

One factory manager who entered into the production of airplanes at the beginning of the war adopted the cabinet system on account of its being used at that time by a larger and older firm. After producing for some time with success the plant was destroyed, and upon moving into temporary quarters to complete the contract, it was attempted to do away with the cabinet by using a more powerful ventilating system. That this was a mistake was promptly realized, for soon production had to be held up to build and install a cabinet. At this writing, the same company is in a new and permanent plant, and is again using cabinets.

The cabinet should be built about 1 ft. longer and 1½ ft. wider than the wings. It should be made to hold six wings or its equivalent, or one complete set, and be about 8 ft. high. Each compartment should have a separate door, and the top of cabinet be covered only with open mesh muslin. Heating should be with steam. Four 3-in. pipes equally distributed at top of cabinet, just under the muslin covering, and each section holding wings should have two 3-in. pipes running the entire length of the cabinet, just under where the wing would lie, and about 1 ft. from each leading and trailing edges. The pipes should be covered, or housed on top, to prevent overheating the portion of the wing immediately over pipes. Each wing section should have two sufficiently stiff channel irons running the entire length of the cabinets for the wings to rest on and be spaced about 4 ft. apart. There should be about 1 ft. of space between the top of the top wing and the muslin covering, with about the same space from the bottom of the bottom wing and floor. Six 2 by 2 ft. grates should be equally distributed on floor to take off fumes. There should be about 6 in. space between each wing when in cabinet, and gravity will take care of the heavily laden air between the wings, as it will flow to the edge and be taken care of by the suction of ventilating system.

The writer has tried a system of drawing hot air in one end of the cabinet and out at the other, each level being perfectly graduated, and found that one end of the cabinet would get too hot while the other would still be cold. The former system is more simple, cheaper, and much better, and only about five changes of air per hour are needed for the cabinet. On large production each cabinet should be placed one behind the other, about 12 ft. apart, to afford a working area. This space should be enclosed at both ends as high as the cabinet, with doors on one end, all windows above being open, to allow plenty of volume for intake, in which case air currents from the main room will not interfere. Each cabinet and working area should have a crew of four men, each crew doping, taping and completing their six wings, or equivalent, every eight hours. Each cabinet and working area will require about 20 by 30 ft. floor space. The wings are doped on trestles, the bottom of wing first. Immediately after this two men each place over the wing a 1 by 3-in. stick, which is made for this purpose, and is one foot longer than the wing chord. The stick has two half blocks nailed on and placed the proper distance apart for the leading and trailing edge to rest on, and the blocks have holes bored for pegs, which are to prevent slipping of wing, and are placed in the holes after the wing is turned. After the two men have turned the wing and placed same on blocks in position, the four men then dope the top side of the wing, after which the wing is picked up by the sticks and placed in the cabinet. The sticks, resting on the channel irons, are left in the cabinet with the wings. The reason for having the sticks one foot longer than the wing chord is to give the two men on the side next the cabinet clearance. The cabinet should be made wide enough to inclose sticks and all. With this arrangement both sides of the wing can be doped in one operation and put in cabinet without being touched by the hands, which is quite an advantage. A temperature of 105 deg. Fahr. will be sufficient at ordinary weather conditions, and will dry the surfaces fast enough to keep the crew steadily at work.

This system is very simple and only requires good team work. It would be advisable, when installing this system in an old plant, to build a false floor about one foot above the old floor, and place the cabinets and working area on this floor. The space between the two floors may be used for drawing off the fumes. This can be done by enclosing this space and with proper graduation of the grates, and would save a great deal of expense in piping. About one-half horsepower to each cabinet and working area will be sufficient for ventilation. Volume propeller fans should be used and not pressure fans. The back, the two ends of the cabinet and all partitions need only be framed and covered with close mesh muslin and given two coats of calcimine to make them airtight. The muslin cover on top of the cabinet should not be calcimined.

Those who prefer to dope and dry surfaces in a vertical position could also use cabinets by merely arranging same and hold surfaces in that position. Above all else, the writer believes the two most essential things are cabinets for drying surfaces and a down-draft system of ventilation by suction only, not even assisted by pressure, especially in working area. Another apparently small but very important thing to be remembered is to keep the eyelets of wings open, especially on the last coat of dope. It is well known that, while surfaces are being doped, the air on the inside is condensed by the cooling action of the solvents, so that on being brought back to normal temperature, after the dope is dry, the air will expand. Now, if the eyelets are closed, the expanding air will stretch and bulge the fabric, so that when the expanded air has been released, the covering will be found to be very loose, hence the demand from aviators, "stretch the cloth tighter."

Some New Enemy Airplanes

The Rumpler C.5 Biplane

The Rumpler C.5 biplane is a general service machine and was used by the enemy at the beginning of the year. It differs only in detail from the earlier C.4 type, an illustrated description of which appeared in the March 15, 1918, issue of AVIATION AND AERONAUTICAL ENGINEERING. With reference to the latter, it may be seen from the accompanying scale drawings that the C.5 type maintains the general shape and disposition of the wings, including the characteristic sweepback and the fitting of ailerons to the upper wings only. The description which follows was prepared by the Technical Department of the British Air Ministry.

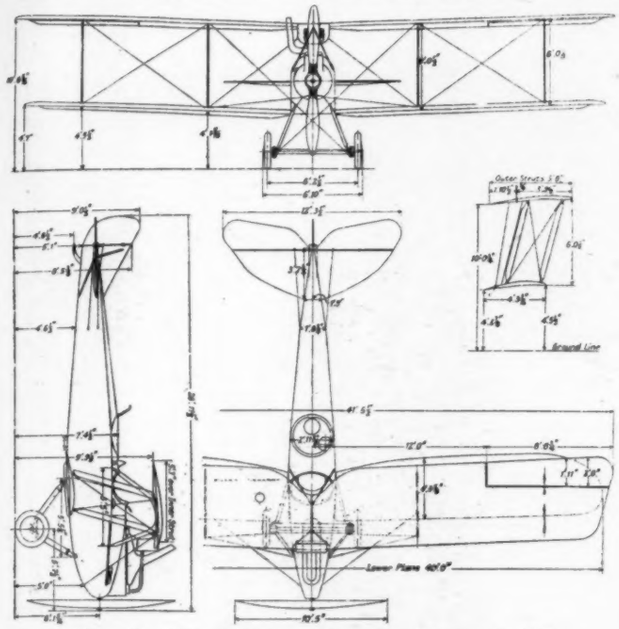


FIG. 1. SCALE DRAWINGS OF THE RUMPLER C.5

The principal characteristics of this machine are as follows: Weight empty, with water, 2439 lb.; weight, fully loaded, 3439 lb.; total military load, 545 lb.; area of upper wings

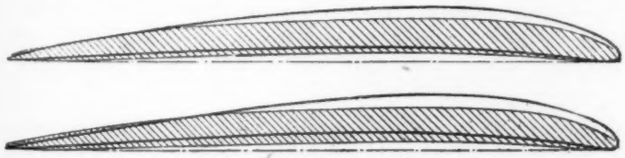


FIG. 2. RUMPLER C.5 AEROFOIL SECTION, WITH R.A.F.14 SECTION SUPERIMPOSED (SHADED)

(with ailerons), 217.6 sq. ft.; area of lower wings, 146 sq. ft.; total area of main planes, 363.6 sq. ft.; loading per sq. ft. of wing surface, 9.5 lb.; area of horizontal fin, 22 sq. ft.; area of vertical fin, 4 sq. ft.; area of elevators, 20.8 sq. ft.; area of rudder, 6 sq. ft.; total weight per horsepower, 13.2 lb.; gasoline capacity, 59 gal.; oil capacity, 3 gal.; water capacity, 10 gal.; endurance, about 4 hr.

PERFORMANCE

	Ft.	M.P.H.	R.P.M.
Speed at	10,000	100.5	1,510
Speed at	15,000	87	1,390

	Ft.	M. S.	Rate of climb in ft. per min.	R.P.M.
Climb to	10,000	16 0	400	1,375
Climb to	15,000			

Service ceiling, 15,500 ft. (estimated).
Estimated absolute ceiling, 17,500 ft.
Greatest height reached, 15,300 ft. in 38 min. 25 sec.
Rate of climb at this height is 125 ft. per min.

CONTROL

Longitudinal (elevators), good.
Lateral (ailerons), very heavy and very ineffective.
Directional (rudder), moderately light and quite effective.
It is reported that the machine is tiring to fly owing to the very poor lateral control; that it is nose-heavy; and rather liable to get into a spin.

Wings—The upper wings have a maximum span of 41 ft. 6 in. and a chord of 5 ft. 8 in. The span of the lower wings is 40 ft., and the chord is 4 ft. 4 in. Ailerons are carried on the upper wings only, the area of each aileron being 15.3 sq. ft.

The wings are swept back through an angle of 3 deg. and are set at 2½ deg. dihedral angle. Both front and rear spars are of spruce, and are constructed in two halves, which are grooved and tongued, and then glued together (Fig. 3). Otherwise the construction of the wings does not afford any novelty.

The methods of attaching the main planes to the upper cabane and to the body, designed to assist rapidity of assembly and dis-assembly, are, however, of considerable interest. They do not differ from the arrangement on C.4 machines, and may be considered, therefore, to have been found satisfactory in practice. From the Fig. 4 it will be seen that the upper wings

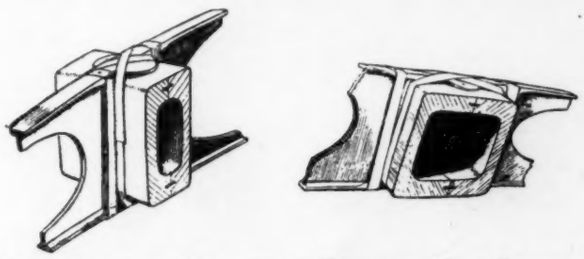
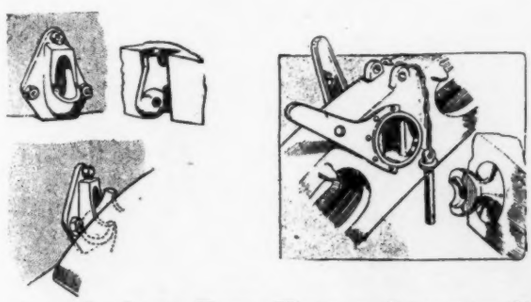


FIG. 3. SECTIONAL SKETCHES OF FRONT AND REAR SPARS AND RIB JOINTS

are locked by means of a guillotine lever, held in position by a pin passing through both levers and through two holes arranged in the center section. The lower wings are locked in position by even simpler means (Fig. 5), requiring no moving parts. The ball at the end of the spar is simply introduced into the socket fixed to the body, and the wing tip is kept lowered. When the tip is raised, the top portion of the wing attachment slips into position, thus locking the wing in such a manner that, even before the attachment of struts and bracing, movement is possible in only one way—that is by the dropping of the wing tip.



FIGS. 4 AND 5. JOINTS FIXING WINGS TO CABANE AND BODY, RESPECTIVELY

Struts—These are circular section steel tubes, encased in a wooden fairing, and are attached to the spars by means of the characteristic German bell-sockets. The construction of the welded-up cabane is shown in Fig. 6.

A cylindrical well of three-ply and aluminum is built into the left lower wing, close to the body, to accommodate the compass.

Body—The body is a compromise between several methods of construction, wire-braced girder work, steel tubing and plywood, all being used in varying degrees.

A braced girder of longerons and cross struts constitutes the principal factor, and this construction is depended upon entirely in the rear of the observer's cockpit. Toward the tail, for a distance of about 6 ft. from the sternpost, the covering is of three-ply, which thoroughly stiffens up the body where the stresses due to the tailplanes may be most severely felt. The middle portion of the body sides—i. e., between the three-

ply at the rear and the pilot's seat, has fabric covering, while forward of this three-ply is again used.

The top fairing is entirely of three-ply, except for the aluminum cowl, which extends to the rear of the gunner's cockpit, as also is the bottom of the body. The engine cowls are of

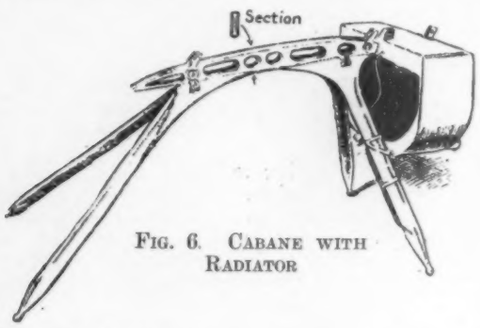
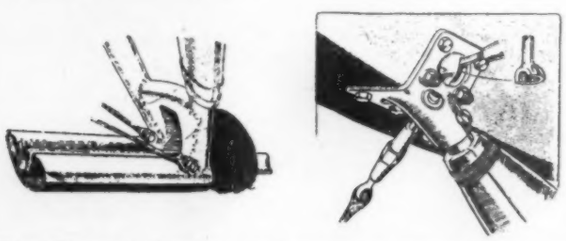


FIG. 6. CABANE WITH RADIATOR

aluminum, held in place by turnbuttons. From the rear of the observer's cockpit to the front of the pilot's seat the wood construction is reinforced by steel tubes, which have forked ends, and are bolted together.



FIGS. 7 AND 8. DETAILS OF LOWER AND UPPER JOINTS OF UNDERCARRIAGE

Undercarriage—The undercarriage, of the usual V-type, is built up of stream-line section steel tubing. At the lower ends the tubes are welded together to form, with the sheet steel axle fairing, the slot to allow for axle travel (Fig. 7). Four bracing wires connect the upper attachment points to the apices of the limbs.

Tail—The tail appears to be built of light steel tubing and is practically of standard German practice; but it is noteworthy that the elevators, which were of the balanced pattern in the C.4 machine, are no longer so. The fin may hardly be regarded as adequate, in view of the side area presented in the

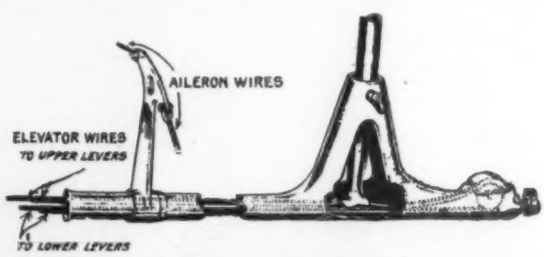


FIG. 9. AILERON AND ELEVATOR CONTROL

nose of the machine, and the report that this airplane is somewhat liable to spin should be considered in this connection.

The four tail stays are of stream-line steel tube, and the lower pair have serrated edges to assist mechanics in remembering that these stays should not be grasped in lifting the machine or in holding it back on starting.

The tail skid is a piece of steel-shod ash, pivoted in the center and sprung at its upper end.

Controls—The control system is of considerable interest, inasmuch as the usual transverse rocking shaft operating the elevator controls is not used. The aileron control is actuated by a longitudinal rocking shaft of steel tube, which carries a welded cone-shaped portion supporting the vertical control lever. The aileron cables are attached to a lever pinned to the rocking shaft, and pass through the wings, operating the ailerons in the way that has become usual in German airplanes —i. e., the aileron lever lies in line with the plane and is accommodated in a slot cut in the rear edge of the main plane.

The control cables pass over pulleys when they leave the lower plane to be attached to the aileron lever. These pulleys are situated behind the rear outer strut attachment, and are capped with a neat aluminum fairing.

The control lever operates the cables attached to the elevator levers, those attached to the lower extremities of the levers passing over pulleys mounted in the front portion of the rock-

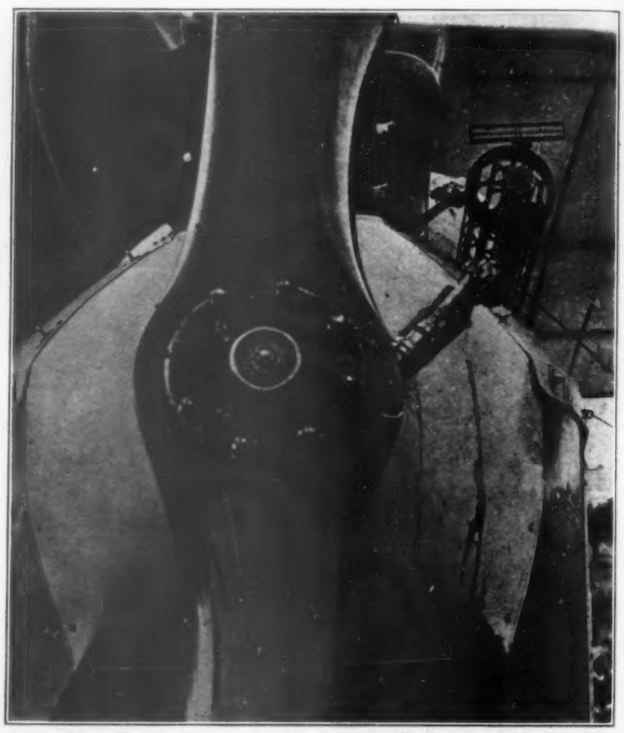


FIG. 10. CLOSE VIEW OF THE NOSE, SHOWING INTERRUPTER GEAR

Photo International Film Service

ing shaft. This shaft projects somewhat below the level of the body bottom, and is neatly faired off by an aluminum shield screwed to the body (Fig. 9).

The rudder bar, of sheet steel, is fitted with rubber sleeves and leather straps to prevent the pilot's feet from slipping off.

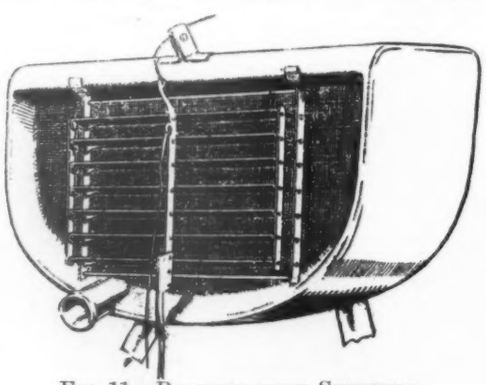


FIG. 11. RADIATOR WITH SHUTTERS

Armament—This consists of a fixed Spandau gun, controlled by the pilot from a thumb lever mounted on the control stick, and a Parabellum gun, which is mounted on the usual built-up wooden ring. There is no bomb rack on this machine, though provision for it had been made.

Engine—The Rumpler C.5 is usually fitted with a 240 hp. Maybach or a 260 hp. Mercedes engine, the machine under review being fitted with the latter. The airscrew is an "Axial" of 3.150 m. diameter and 1.830 m. pitch.

Cooling System—The radiator, which is fixed to the cabane, is of the honeycomb type, with brass tubes expanded at their ends into hexagons and sweated together (Fig. 11). The total radiating area is approximately 1.5 sq. ft. The shutters which regulate the cooling surface are controlled by cables passing over pulleys and exerting direct pull.

The temperature of the water is indicated by a mercury thermometer easily visible from the pilot's seat, and the limits of the permissible range of temperature are defined by red marks—one at 60 deg. and the other at 85 deg.

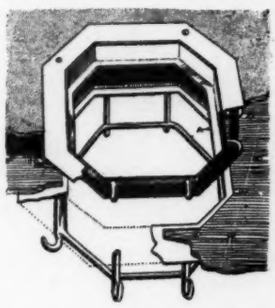
The oil tank is situated at the port side of the engine, and the maintenance of an equable temperature of its contents is assisted by a thick covering of felt.

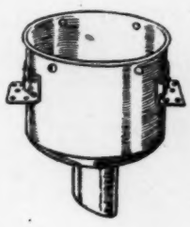
Fuel System—The main gasoline tank—of 46 gal. capacity—serves as a support for the pilot's seat, while an auxiliary tank holding 13 gal. is fitted between the two cockpits, adapting itself to the shape of the body top fairing and to the gunner's turret.

The initial pressure is obtained in both tanks by means of hand pumps, of which there is one in each of the cockpits. An automatic air pressure pump driven off the crankshaft maintains the pressure, and a release valve incorporated in the pump regulates it. Each tank has its own pressure gage on the dashboard.

Engine Controls—Three three-way cocks are fitted. They enable the pilot to shut off the gasoline entirely; to supply from both tanks simultaneously, or to run on either of the tanks alone.

Wireless—The machine is internally wired, and a tapping key is fitted to the gunner's right hand. The rack intended to support the aerial reel is also to be found, as well as a sheet steel dynamo shelf near the engine.





FIGS. 12 AND 13. TRAY AND WELL FOR CAMERAS

Cameras—Two types of cameras were fitted. One, particularly large, was accommodated in the special fitting shown in Fig. 12. The light octagonal tray A is suspended from the floor boards by elastic shock absorbers. The zinc well shown in Fig. 13 carried the second camera.

The Economics of Aerial Transport

When the subject of the regular civilian use of airplanes for public service or for the carriage of mails or light goods comes up for discussion, there are plenty of people who think that the whole matter can be settled by merely stating that the airplane has too limited a carrying capacity, and costs too much to operate.

Now, the airplane's carrying capacity already compares not unfavorably with that of a fairly substantial motor chassis, and the high cost of operation is by no means a foregone conclusion, if we take into account the fact that time is of value, and that expenditure upon handling and transhipment en route must always be added to the actual running costs of the methods of transport employed.

The fact of the matter is that the actual cost of running a conveyance must not be confused with the cost of carrying people or goods by its means. The one is merely a part of the other, and the percentage that it represents may be small or great.

For one thing, we must remember that a journey by a passenger involves incidental expenditure more or dess proportional to the time occupied. If a journey cannot be completed in one day, hotel expenses must be added to the cost of the ticket.

Fuel and oil are not the only items. The airplane may also be more expensive as regards repairs and depreciation. On the other hand, it does not wear out tires or add to the cost of maintaining the public roads.

A trained pilot for a long time to come will be a more expensive luxury than a motor driver, and altogether the running costs of the airplane will probably be appreciably larger than those of the car.

For that matter the running costs of a car, per passenger carried, are appreciably greater than those of a railway train, but the latter does not get all the traffic. Similarly, the costs of rail transport are considerably greater than those of canal or coastwise transport, but again the more expensive method is frequently preferred as being more rapid, direct and convenient.

In short, the question of whether any particular means of transport is commercially sound cannot possibly be settled simply by comparing its cost with that of other methods. To do this is to ignore altogether the value of time, merely because in the great majority of instances it cannot figure in an ordinary statement of accounts.

There still remain countries in which the value of time is not appreciated by the natives. In such countries the provision of rapid traveling facilities are dependent upon the colonizing element. The creation of such facilities is a very long and expensive job, and if the number of people likely to make use of them is comparatively small, then the interest on the capital outlay is very high per head or per mile covered.

Let us illustrate this point by taking an extreme case. A single passenger desires to travel a distance of several hundreds of miles from one point inland to another point inland, across uninhabited or uncivilized country. A sea passage is out of the question. Nobody but a lunatic would suggest laying down a railway simply for conveying that one passenger. To propose the construction of a road would be almost equally mad.

We are, therefore, reduced to a choice between two alternatives—the most ancient and the most modern methods of traveling; that is to say, the beast of burden and the airplane. If the former method is adopted the time taken on the journey is immense, and the cost of living must be added to the estimated value of the time and to the cost of providing and feeding the necessary beasts. If an airplane were available it would unquestionably offer infinitely the cheaper method of transit.

Now gradually increase the demand for traveling facilities. Sooner or later a point may be reached at which the traffic is sufficiently great to justify the construction of a road on which motor vehicles may run. If it develops still further, it may again justify the construction of a railway, but this only happens when the interest on the capital expenditure involved in the construction of the railway line represents a smaller amount than the difference between the operating costs of the road and the rail traffic.

Between points on the seaboard transport can be arranged without heavy capital expenditure on creating a track or heavy annual expenditure upon maintaining it. Docks and piers may have to be constructed and harbors improved.

For overland transport the airplane is in rather the same position. Its track is ready for it, and needs no creation or maintenance. All that is necessary is the provision of landing grounds and repair bases.

The capital expenditure involved is trifling. The time saved is enormous. It would then be perfectly ridiculous merely to compare operating costs with those of other methods of land transport when once established.

We see then that under some conditions the airplane will actually be the cheapest method of transport. Under other conditions it will not be the cheapest, but will still be chosen because it is the quickest, and the traveler's time is worth money. It will then compare with road or rail transport in somewhat the same way as the telephone or the telegram compares with the postal service.—"Medway" in *The Aeroplane.*

The Examination of Aviators*

By R. A. Bachmann, Surgeon, U. S. N.

The examination of aviators presents many new points which differ from the usual physical examinations given to officers and enlisted men.

Flying is a new science and new faculties are brought into play, the soundness of which must be determined in the applicant. In addition to physical fitness, the emotional apparatus must be tested.

The Army Signal Corps has adopted a very complete procedure in examining its flyers and in this article liberal extracts will be made from the examination blank and its general form followed.

A new departure in physical examinations is the introduction of the Bárány tests for determining the condition of the vestibular function. Prof. Bárány originally devised these tests some years ago, but the modified technique employed at present and the application of the same to the examination of flyers is the work of Drs. Randall, Jones, Fisher, and Gile, of the University of Pennsylvania.

It will be noted, too, that the former physical examinations have been amplified and elaborated in many other respects.

In flying, the human body is pursuing such an unusual occupation in such an unusual environment that ordinary methods of examination must necessarily prove inadequate. It must be borne in mind, also, that flying being a new science, new experiences are bound to accumulate, which will in all probability produce many future changes in the present proposed method of physical examination.

That the examination ought to be thorough and searching seems to be self-evident. It will be observed that a good many of the eye and ear tests are of German and Austrian origin. What these countries have done along this line since the war no one knows but it is sound military judgment to assume that their flying corps has been very carefully selected. We must meet this condition by an equal care in the selection of our men.

A tentative routine would be somewhat as follows:

General Examination

1. Height, ... inches. Weight, ... pounds.
2. Chest, ... expansion. ..... inspiration.

Follow Bureau of Navigation M. and S. Circular 125221, March, 1917: Instructions for Physical Qualifications Required for Appointment for Aeronautic Duty in the Navy or Marine Corps.

3. Lungs.
4. Bones and Joints.
5. Skin.
6. Nervous System:
   Reflexes of knee ..... elbow ..... ankle .....
   Vertigo.
7. Vascular System.
   (*a*) Pulse.
   (*b*) Arteries.
   (*c*) Blood pressure—systolic—diastolic.
   (*d*) Heart.
8. Digestive system:
   Vomiting.
9. Urinalysis:
   Shreds.
   Specific gravity.
   Reaction.
   Casts.
   Sugar.
   Albumen.
10. Wassermanns.

11. *Dynamic tests.*—(*a*) Walking: This test should be done by having applicant, with closed eyes, walk forward, barefooted, 20 feet and backward to point of starting. A straight line should be followed.

(*b*) Romberg: Maintain position for one minute without swaying.

12. *Eyes—History of eye trouble—Visible lesions.*—Question the candidate carefully regarding previous or present eye trouble, use of glasses, headaches, lacrymation, scotoma, and photophobia; also diplopia (museae volitantes, panorama symptoms), glaucomatous symptoms, night blindness or asthenopia when not wearing correcting lenses. Any one of the latter group disqualifies and also of the former group, if marked. Note findings.

13. *Stereoscopic vision.*—Stereoscopic vision is the ability to appreciate depth and distances by means of binocular single vision. Objects printed on the test cards furnished for use with the steroscope are drawn to scale, the distance between corresponding points of similar objects are equal; between dissimilar objects, unequal. They are seen at different apparent depths, the result of superposition of each two similar images in space; the less the distance between the objects, the nearer they appear to the observer's eyes; the greater the distance between, the farther away they appear. A normal eye can appreciate an apparent difference in distance between stereoscoped objects of 0.01 millimeter. Adjust the oculars of the stereoscope at their focal distance (15 centimeters) from the glass stage and rotate by means of the milled edge on either ocular cup so that the interpupillary distance will be as great or greater than the distance between any two similar points of objects to be stereoscoped. With good illumination, have the candidate name the sequence of objects from front to rear as he sees them through the stereoscope. This should be done readily and without error, otherwise it is a cause for rejection.

This test is best made by test card devised by Zeiss, of Jena. Bausch and Lomb probably have similar cards.

14. *Ocular movements.*—Ocular movements are tested roughly by requiring both eyes of the candidate to be fixed on the examiner's finger, which is carried from directly in front to the right, to the left, up and down. The movements of each eye must be regular and identical.

15. *Pupillary reactions.*—R..... L.....

Pupillary reactions should be regular and equal in each eye when responding to (1) direct and (2) indirect light stimulation and (3) to accommodation. Face the candidate and place a card as a screen before both eyes. Uncover one eye after a short interval and allow light to shine in this eye. The resulting contraction of the iris of this eye is called direct. Repeat, but now observe the shaded eye. This reaction is indirect or consensual of the shaded eye. Repeat for the other eye.

With both the candidate's eyes open and uncovered, have him fix on a pencil held a few inches directly in front of him; bring the pencil toward him until it nearly touches his nose. Both irises will contract, which is called the reaction to accommodation.

16. *Intraocular tension.*—R..... L.....

Intraocular tension is tested roughly by palpation. With the candidate looking down, palpate the eye through the upper lid with the index finger of each hand, and compare the tension with the other eye and with an eye believed to be normal. If not normal it is a cause for rejection.

17. *Nystagmus.*—Ocular nystagmus is determined, and if it is rythmical and occurs ..... (*a*) and (*b*) ..... on looking straight ahead or laterally, 40 deg. or less, it is a cause for rejection.

Spontaneous ocular nystagmus produced by extreme lateral sight, 50 deg. or more, is not a cause for rejection, as it is found in the normal individual. It is usually manifested by a few oscillating lateral movements, never rotary, which appear when the eyes are first fixed in extreme lateral positions. Select a scleral vessel near the corneal margin as a point for observation.

18. *Field of vision.*—R..... L.....

Field of vision is tested separately for each eye. Place the candidate with his back to the source of light and have him fix the eye under examination (the other being covered) upon the examiner's, which is directly opposite at a distance of 2 feet. The examiner then moves his fingers in various directions in a plane midway between himself and the candidate, until the limits of indirect vision are reached. The examiner

* Courtesy of the U. S. Naval Medical Bulletin.

thus compares the candidate's field of vision with his own and can thus roughly estimate whether normal or not. A restricted field of vision should be confirmed by the use of a perimeter, as it would then be a cause for rejection.

19. *Color perception.*—This should be made with the Jennings test cards. In this test the yarns are fastened to a card —each shade beside a perforation. The candidate punches through the perforation and makes a record card. There is no guesswork, a permanent record is made and the scientific arrangement of the confusion colors insures proper application of the test.

20. *Muscle balance, at 20 feet.*
Hyperphoria.
Exophoria.
Esophoria.

If available, a phorometer should be used to determine the absence or presence of a muscular imbalance. Adjust the phorometer close to and in front of the candidate's eyes, 20 feet distant from a lighted candle or other small point of light on the same level. Darken the room and arrange the prisms so that their bases are situated inward; two images of the light will then be seen displaced laterally. If on a level, there is a normal balance of the vertically acting extrinsic eye muscles or orthophoria; if not on the same level, there is vertical imbalance or hyperphoria; left if the left image is below, right hyperphoria if the right image is below. Read off on the scale the amount necessary to bring the images on the same level.

Repeat the test with the prisms, one up and one down. If the images are now directly above each other there is no lateral imbalance, but if laterally displaced and on the same side with the eye seeing each image, there is homonomous diplopia due to a lateral imbalance called esophoria. If the images are crossed there is exophoria. Read off on the scale the amount necessary (prism diopters) to bring them in the same vertical meridian. If not more than 1 deg. of hyperphoria and more than 2 deg. of esophoria or exophoria, the test is satisfactory.

21. *Visual acuity.*—(*a*) Snellen's type (20 ft.).

Require 25/20 for each eye. There is no reason why the requirements for gun pointers should not be applied to aviators.

(*b*) Near point.—Right..... Left.....

Acuity for distance tested at 20 feet from a well-illuminated Snellen test card. Less than 25/20 in either eye, tested separately, disqualifies.

Near point, of acuity of vision, is determined separately for each eye by requiring the candidate to read in a good light the Jaeger No. 1 test type, first gradually bringing the card toward the uncovered eye until the nearest point to the eye, at which the test type still remains distinct, is reached. The distance of this point from the anterior surface of the cornea, measured in centimeters, is the near point. Greater than 11 centimeters at 20 years of age, greater than 13 centimeters at 25 years of age, or greater than 15 centimeters at 30 years of age, disqualifies.

22. *Ophthalmoscopic findings.*—Drop one drop of a 5 per cent solution of euphthalmine in each eye. Have the candidate keep his eyes closed. After 15 minutes repeat the drops; examine 15 minutes later. A pathological condition of the fundus, active or quiescent, is cause for rejection.

23. *Ears—History of ear trouble.*—(*a*) Discharge, ... Buzzing, ringing, or noise, ... Vertigo, ... Seasickness, ... Cranial injury, ...

24. *Appearance of ex-auditory canal.*

25. *Appearance of membrani tympani.*

Ear Determination

Hearing should be normal for each ear. To determine this both the whisper and watch tests are used. After examining both external auditory canals and membranæ tympani by means of a speculum and a good light (first removing wax if present) for abnormalities, such as small and tortuous opening, presence of pus, perforation, scars, retraction, or other evidence of past or present inflammation, which are causes for rejection, the candidate is required to stand at 20 feet from the examiner, facing away from him. An assistant closes the ear not under examination with his moistened index finger pressed firmly into the external auditory meatus. The examiner facing the back of the candidate exhales, and then, with his residual air, whispers numbers, words, or sentences which the candidate should repeat. The other ear will then be tested in a similar manner. If unable to hear, the examiner will approach until the candidate does hear, the distance being recorded in feet. If less than 20 feet, it is a cause for rejection. A quiet room is essential.

The watch test is preferably made with a loud-ticking watch such as the ordinary Ingersoll, which, while variable, should be heard at about 40 inches. Any watch used should have been previously tried out on at least five normal persons and the distance heard made a matter of record. The number of inches in distance heard by the candidate, eyes closed and opposite ear occluded, is taken as the numerator and the distance the watch should be heard as the denominator. This should be the equivalent of 40/40; less hearing than this disqualifies.

26. *Examination of Eustachian tubes—per catheter.*

27. *Examination for diseased tonsils, adenoids, etc.*

Equilibrium (Vestibular)

28. *Equilibrium* (vestibular). Head tilted forward 30 deg. to level horizontal canal, using *Bárány* chair. Eyes closed. Rotation nystagmus normal, 26 seconds; a variation of 10 seconds under and 6 over is allowable.

(*a*) Right: Applicant to be turned toward his right, 10 turns in exactly 20 seconds; horizontal nystagmus to left for ——— seconds, amplitude.

Left: Applicant to be turned toward his left, 10 times in exactly 20 seconds; horizontal nystagmus to right for ——— seconds, amplitude.

Always test for spontaneous nystagmus before rotating.

(*b*) Pointing tests:

(1) Before turning.
Right arm, ———.
Left arm, ———.

(2) After turning 10 times in 10 seconds to right.
Right arm, ———.
Left arm, ———.

(3) After turning 10 times in 10 seconds to left.
Right arm, ———.
Left arm, ———.

(*c*) Falling tests:

(1) Turn to right, 5 turns in 10 seconds.
Falls to, ———.

(2) Turn to left, 5 turns in 10 seconds.
Falls to, ———.

If applicant is disqualified, use douche tests in every case.

The nystagmus, past-pointing and falling, are tested after turning. The turning-chair must have a headrest which will hold the head 30 deg. forward, a foot rest and a stop-pedal. Use a stop watch.

(*a*) Nystagmus. Head 30 deg. forward; turn candidate to the right, eyes closed, 10 times in exactly 20 seconds. The instant the chair is stopped, click the stop watch; candidate opens his eyes and looks straight ahead at some fixed distant point. There should occur a horizontal nystagmus to the left of 26 seconds' duration. Candidate then closes his eyes and is turned to the left; there should occur a horizontal nystagmus to the right of 26 seconds' duration.

(*b*) Pointing. (1) Candidate closes eyes, sitting in chair facing examiner, touches the examiner's finger held in front of him, raises his arm to perpendicular position, lowers the arm, and attempts to find the examiner's finger. First the right arm; then the left arm. The normal candidate is always able to find the finger. (2) The pointing test is again repeated after turning to the right, 10 turns in 10 seconds. During the last turn the stop pedal is released and as the chair comes into position it becomes locked. The right arm is tested, then the left, then the right, then to the left until he ceases to past-point. The normal will past-point to he right 3 times with each arm. (3) Repeat pointing test, after turning to the left.

(*c*) Falling. Candidate's head is inclined 90 deg. forward, forehead to knees. Turn to the right, 5 turns in 10 seconds. On stopping, candidate raises his head and should fall to the right. This tests the vertical semicircular canals. Turn to the left, head forward 90 deg.; on stopping, the candidate raises his head and should fall to the left. Unless each test is normal, it is a cause for rejection. Examination room should have apparatus for hot and cold douching of ear and for examination of drums.

In addition to the five senses ordinarily classified as special senses, the flyer uses his "muscle-joint-and-splanchnic" sense, and a seventh—the so-called "static sense."

Equilibrium is the result of a combination of the sight muscle and static senses. Of the three, the most directly concerned in balance is the latter, while the sight and muscle senses are only indirectly concerned.

This static sense has for its special organ the vestibular apparatus and the Bárány test as modified by the University of Pennsylvania workers gives a clear-cut picture of the condition of this organ so important to the aviator.

For instance, in the matter of high flying or flying in the dark the static sense becomes at once practically the only means of maintaining the correct relation of his machine and of himself, to the earth.

Again in performing some difficult evolution or a series of hazardous turns, such as must surely fall within the experience of any flyer engaged in active duty, a perfect equilibrium sense is necessary to gauge correctly the speed, direction and length of motion followed in performing the loop or turn.

It will be noted that the normal nystagmus is 26 seconds. A variation from this of 10 seconds down and 6 seconds up is permitted.

A particularly sensitive ear registering, for example, 34 seconds, might be too easily afflicted with vertigo and thus prove undesirable. Thirty-two seconds would at present appear to be a safe high limit. The effect, of course, of repeated flights is, that tendency to vertigo is reduced as the barin becomes accustomed to registering certain normal (to flying) disturbances or impressions in the canals.

The chairs used in the nystagmus and past-pointing tests are of a special design, so that they can be turned easily by means of a turning rod, fitted with a handle, projecting from the back. A pedal mechanism releases the chair for revolving and brings it to a sudden stop after the required number of revolutions. The chair must be stopped suddenly or the experiments will fail. The turns must be counted and timed accurately.

The eye and ear tests should be made only by a specialist in those branches. If the Bárány tests fail the candidate is always put through the ear douching test before final rejection. In this test the eardrum is first inspected for perforations or other pathological conditions, and when found intact, a nozzle is inserted into the canal and water at a temperature of 68 deg. Fahr. is permitted to flow against the drum. With the head bent at an angle of 30 deg. forward, the endolymph of the vertical canal is put in motion through cooling of the lower parts, on the thermosyphon principle, and causing a vertical nystagmus, a flow is produced. By turning the head backward or letting it fall forward, the horizontal canals are similarly affected. Nystagmus begins in about 20 seconds. If after four minutes of douching no results are produced the flow of water is stopped.

Psychological Tests

The psychological tests are made either by a Hipp chronoscope or a d'Arsonval chronometer.

The Hipp chronoscope is practically the same as the d'Arsonval chronometer and can be used for exactly the same purpose. The chief difference is that the clockwork of the Hipp instrument is actuated by a weight and that of the d'Arsonval by a spring mechanism. The Hipp is more accurate, giving its readings in the 1/1000 of a second, the d'Arsonval in the 1/200.

The manner of taking the reaction is the same in both—a visual, auditory, or tactile signal is given depending upon the psychological reaction desired, which automatically breaks the current; the needle revolves, the subject presses a key, the current is connected again, and the needle stops. The reading is taken from a dial. The dial of each is scaled in 100 divisions, but in the Hipp the needle revolves around the full dial in 1/10 second, while in the d'Arsonval it makes the circuit in 1 second. In the Hipp the nature of the signal is left to the choice and requirements of the operator.

There is a Hipp chronoscope in use at the psychological laboratory of the University of Pennsylvania.

The value of these psychological reactions is still debatable. It seems to be desirable that some form of tests be made to determine judgment and emotional control in the applicant. As for the latter, it would appear to be reasonable that this testing could best be made during the stage of apprenticeship which the flyer undergoes. The various emotional disturbances which the beginner experiences react on him considerably and the teacher usually becomes quickly cognizant of them. Those who show inaptitude in this respect could be weeded out at the aviation camps. A medical officer's supervision is always at hand at every flying camp, and he could be utilized to assist the instructor in making observations. At present, the method employed of producing a sudden shock, such as shooting a pistol or creating some other loud noise suddenly behind the unexpecting candidate does not meet the requirements.

To establish the presence of normal judgment in a candidate is not easy, yet very necessary. Judgment of distance, time and speed enter considerably into flying in all its phases. A crude attempt to obtain some means of measuring this mental attribute was made recently at the Naval Hospital, Philadelphia, Pa.

Two sticks, twenty-seven inches and twenty inches long, respectively, were hung on a wall; a board with three revolving 9-inch disks, each disk revolving at a slightly different rate of speed, was made; and an 8-inch wooden square was sawed in seven pieces. A sand watch was also used.

To determine distance judgment, the candidate was required

The Thirty Poorest

	Name.	Rate.	Occupation.	Age.	Blocks (minutes).	Sticks (inches).	Disks.	Watch (minutes.)	Remarks.
1.	H., E. J.	HA	Conductor, high school	19	7	34-24	1/3	3	
2.	O., J. S.	HA-1	3 years drug clerk, ninth grade P	23	35	24-18	1/3	2½	Dull; slow of comprehension.
3.	S., W. D.	Ch. Y	Stenographer B.C., grammar school	20	112	40-30	1/3	5	
4.	F., E. H.	Ch. Y	Stenographer, high school	20	185	25-18	3/3	15	
5.	N., J. F.	Sea	Iron worker	24	21	30-22	1/3	32	Very poor idea of time space.
6.	W., S.	HA	1 year college, assayer	24	34	24-16	0/3	0	
7.	R., E.	Pvt. M. C.	Laborer	22	487	25-21	0/3	13	Very sluggish mentally; seems to comprehend, but to be unable to carry out his thought.
8.	E., R.	HA	Printer	20	23	36-24	0/3	6	
9.	N., J. N.	F-2	Laborer	23	425	15-13	0/3	58	Patient seems to be a high-grade imbecile; very inattentive.
10.	P., W. W.	HA	High school	19	23	24-18	0/3	10	
11.	R., W.	MsA-2	Packer (negro)	18	195	25-16	1/3	14	Nervous and inattentive.
12.	G., T. E.	HA	Molder	19	82	30-24	0/3	4	Nervous and a little dull of comprehension.
13.	J., A. W.	Ph.M-2	Druggist	26	82	27-19	0/3	15	
14.	B., J. D.	HA-1	Clerk	19	29	24-12	1/3	36	
15.	G., H.	HA-1	1 year college	24	83	28-16	1/3	12	
16.	R., E.	Sea	Mechanic	21	19	28-19	1/3	5	
17.	N., K.	HA-1	Lineman	23	19	30-20	1/3	2	
18.	W., H. E.	HA-1	Clerk	18	38	24-18	0/3	7	
19.	C., D. H.	Ph. M-2	4 years high school	22	82	26-19	1/3	10	
20.	K., J. J.	Ch. Y	Real estate, high school	25	60	36-24	0/3	5	
21.	H., F. C.	Asst. surg.	M.D., assistant surgeon	22	29	36-22	1/3	3	Slow.
22.	H., J. J.	Asst. surg.	Student, M.D.	24	46	24-18	0/3	5	Slow; slow to comprehend.
23.	C., C.	Asst. surg.	Student, M.D.	30	88	30-18	3/3	0	Failed to comprehend block test.
24.	M., W. T.	Sea-2	Clerk	25	62	24-15	3/3	6	
25.	M., W. B.	W. T.	Locomotive engineer	32	122	24-18	1/3	15	Lost position because of accident.
26.	A., H. A.	M-1	Clerk	24	242	18-12	3/3	20	Very dull of comprehension; mentally slow; apparently nervous.
27.	T., J. C.	HA-1	Salesman, 4 years high school	20	152	24-18	3/3	8	
28.	H., B. F.	El-2	Moving-picture operator, 1 year high school	25	370	30-24	0/3	5	
29.	U., L.	Ph. M-2	Clerk	23	186	36-24	1/3	3	Filipino.
30.	T., T. V.	HA-1	Clerk	21	30	26-18	0/3	3	Not athletic.

to estimate the length of the two sticks, after having been shown a yard-stick. To determine time judgment, he was required to estimate the length of time it took for a certain amount of sand to run back after he had been permitted to see it flow into the empty compartment. The operator tried to approximate a half minute in the filling.

"Arrangement judgment" was gauged by the length of time required to arrange the sawed pieces of wood into a perfect square. Speed judgment was measured by the candidate's ability to range the disks in the order of their speed. The diameter of the blocks, attached to the disks, which carried a string belt imparting motion to them, was 5½, 6, and 6½ inches. Thus they moved almost at the same rate of speed.

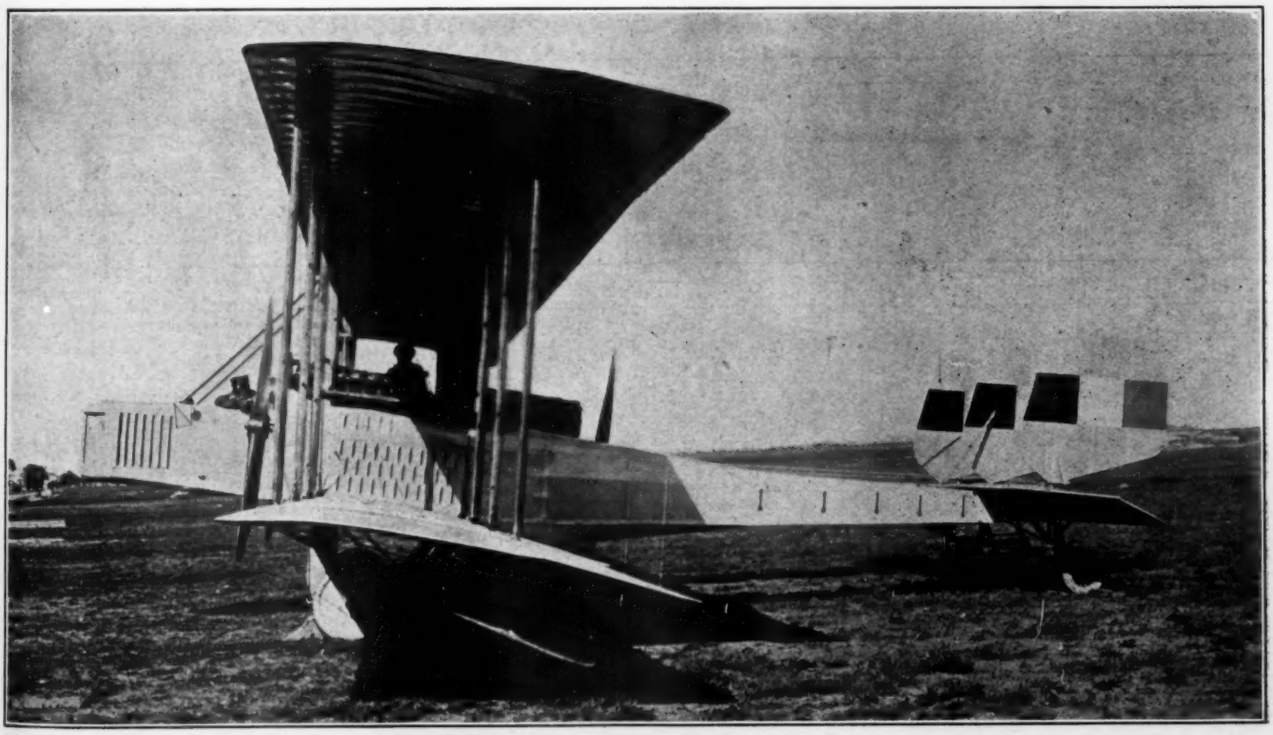
A hundred men were examined and the results tabulated. The 30 best results and the 30 poorest are appended. All of the latter missed at least two tests by a big margin. Of the 30 best ones, none took more than 30 seconds on the blocks excepting No. 11, a man 47 years of age. All of them ranged the disks correctly. The watch test exceeded 10 seconds in only five instances. The average error in guessing the length of the two sticks exceeded 10 inches only once.

In the 30 poorest it was exceeded nine times. These figures warrant, I think, the conclusion that tests of judgment are possible, especially if better mechanical appliances are used instead of the crude, makeshift objects hurriedly devised for making the above tests.

The points I wish to emphasize in conclusion are that an eye and ear specialist should conduct the examinations of these organs, that the Bárány test should be accurately made with a well-constructed chair by an ear specialist, that abnormal emotional disturbances should be noted by observation during the apprentice period, that judgment tests can be applied but are difficult of standardization, and finally that a standard examination chart should be furnished to make the examination of aviators complete, thorough, and uniform.

The Thirty Best

1.	T., M. H.	HA-1	Student, 2 years college	23	10	30-18	3/3	15	Quick of comprehemsion; speedy in replies; football; runner.
2.	S., C. L.	HA-1	Student, 3 years college	22	10	28-14	3/3	2	Fairly quick at comprehension; football; runner.
3.	H., A. W.	HA-2	Student, 1 year college	20	11	20-14	3/3	1	Fairly quick at comprehension; some athletics.
4.	P., W. D.	HA-1	Printer	20	14	32-20	3/3	2	Mentally alert; basket ball.
5.	O., W.	HA-1	Salesman, 1 year high school	22	9	27-18	3/3	6	Track athlete; football; swimmer.
6.	L., W. F.	HA-2	Printer, 1 year high school	18	10	24-18	3/3	3	Quick at comprehension; basket ball; swimmer.
7.	K., W. D.	Pvt., 1st Pa.	Machinist	28	11	27-20	3/3	7	
8.	W., S. W.	Lieut.	Engineer	33	28	26-16	3/3	6	
9.	S., R. S.	Bugler	Vocalist	29	21	32-21	3/3	4	
10.	E., G. D.	Sea-2	Machinist, student	19	11	27-18	3/3	3	
11.	A., A. M.	1st serg.	Clerk	47	11	30-24	3/3	5	
12.	R., F. H.	CMM.	Machinist	31	15	31-25	3/3	5	
13.	W., G.	Sea-1	Machine helper	19	25	27-16	3/3	3	
14.	L., W.	Sea-2	Plasterer	19	15	27-17	3/3	4	
15.	S., A. A.	Asst. surg.	Clerk, student	26	22	26-18	3/3	1	
16.	L., E. F.	Asst. surg.	Teacher, student	30	14	24-18	3/3	13	Good judgment and poise.
17.	E., C. J.	Asst. surg.	Student	28	11	26-18	3/3	4	
18.	N., C. S.	Asst. surg.	Student	27	12	28-22	3/3	8	Baseball.
19.	R., H.	Asst. surg.	Student	25	8	26-18	3/3	6	
20.	G., E.	HA-1	2 years college, pharmacy	22	10	30-24	3/3	12	Track; alert.
21.	B., F. F.	HA-1	Clerk	22	23	29-17	3/3	8	
22.	T., H.	HA-1	4 years high school	18	12	28-18	3/3	4	Alert; some athletic work.
23.	D., J. M.	HA	Clerk, 2 years high school	24	6	28-20	3/3	20	
24.	T., O. G.	HA-1	4 years high school	18	16	28-18	3/3	10	Basket ball.
25.	E., E. W.	HA-1	4 years high school, clerk	19	9	22-18	3/3	3	
26.	V., M. L.	Pvt. M. C.	Collector	20	13	24-16	3/3	2	Athlete; high jumper.
27.	V., N.	HA-1	2 years high school	18	9	28-18	3/3	1	Y. M. C. A. track team; basket ball
28.	H., J. O.	Y.-3	4 years high school, clerk	21	8	28-18	3/3	15	All around athlete.
29.	L., R. H.	Asst. surg.	Hard work, student	25	14	24-15	3/3	5	Not athletic.
30.	k., P.	Asst. surg.	Student	25	8	28-18	3/3	3	Athlete.



SIDE VIEW OF THE FIRST THREE-ENGINED LIBERTY-CAPRONI BOMBER, BUILT BY THE STANDARD AIRCRAFT CORP.
(C) *Committee on Public Information*

The 300 hp. Maybach Engine*

Ignition—The two Bosch Z.H.6 type magnetos are mounted on brackets cast on the rear end of the base chamber, and are driven at 1.5:1 engine speed directly off the rear end of the camshafts. The ignition point is set 38 deg. early. Two Bosch 3-point plugs are somewhat inaccessibly fitted in the head of each cylinder between the twin water connections as previously described. The plug bosses are water-cooled. The high tension

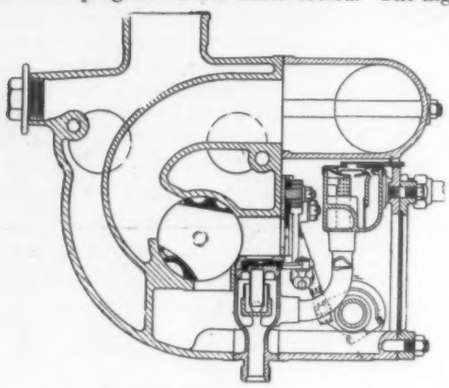


FIG. 25. CROSS-SECTION OF CARBURETER

cables are carried in fiber tubes bolted to the cylinders, and the leads to the plugs are taken through fiber blocks mounted on the sheet-metal brackets on the cylinder heads.

Order of firing—1-5-3-6-2-4

Carbureters—The two carbureters are attached to the heads of the front and rear cylinders, as already described, and their general construction is shown in the cross-sectional drawing, Fig. 25.

These carbureters are designed to be used in conjunction with a gasoline pump system, and in place of a float chamber employ two small constant-level overflow tanks inside each carbureter. This method obviates the necessity for using pressure release valves in the gasoline system. Referring to

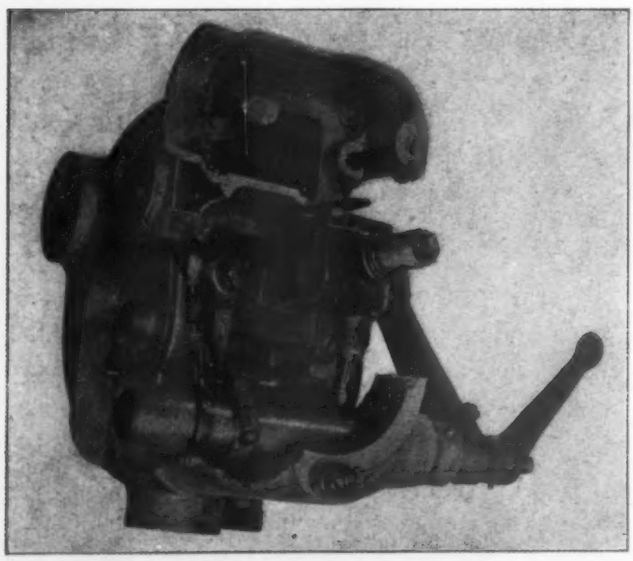


FIG. 26. ONE OF THE CARBURETERS BROKEN TO SHOW INTERNAL CONSTRUCTION

the sectional drawing of the carbureter, Fig. 25, they are constructed of a cast aluminum, water-jacketed body, in the center of which is mounted the rotary barrel-type throttle, open on one side to the curved passage to the induction pipe, and on the other to the mixing chamber above the jets. The main air supply is taken through a passage cast in the aluminum carbureter body directly below the throttle, and the extra air supply is automatically controlled by a guillotine type shutter, which works vertically just in front of the jet control lever. The throttles of both carbureters, together with the mechanically controlled jets and the extra air shutters, are all interconnected. The arrangement of these cranks and interconnecting levers is shown in the photograph of the specially sectioned carbureter, Fig. 26.

The working principle of the carbureters and the functions of the various parts is more clearly demonstrated in the purely diagrammatic sectional drawing, Fig. 27, which is, to a great extent, self-explanatory. Gasoline is delivered by the fuel pump into the small tank A of each carbureter through a restricting jet B, shown in the diagram. The gasoline in these small tanks or reservoirs is kept at a constant level by means of the overflow pipe C, which leads back to the main fuel tank, via the small, lower tanks D below the jets, which are supplied through the pipe E. An air vent F, fitted with a

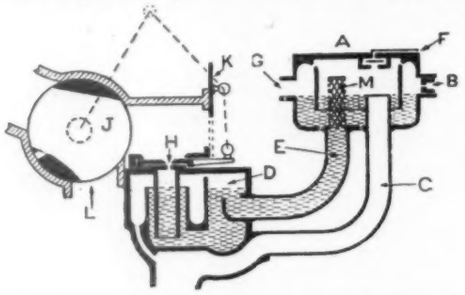


FIG. 27. DIAGRAMMATIC SECTION OF CARBURETER

baffle plate, is provided in the top of the constant level tank A, which is also connected to the main gasoline tank by a pipe G, leading to a hand gasoline pump, or may be plugged and not used, as was the case in the Rumpler biplane. The main and pilot jets consist of two holes drilled in the top cover of the lower reservoir D, and are similar in principle to the White and Poppe jets. The area of the jet openings is mechanically controlled by means of a small hole drilled eccentrically in the jet cap H, which, as previously described, is connected by levers to the throttle and air control levers. The function of the top tank A is apparently to deal with the large excess of gasoline delivered by the gasoline pump at high speeds, while the lower tank, which is gravity fed, provides a constant petrol level for the jets.

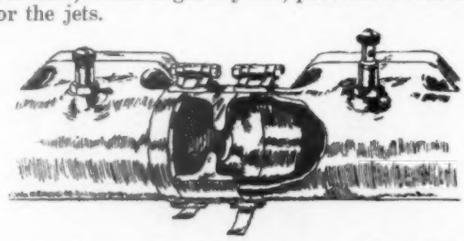


FIG. 28. INDUCTION PIPE BAFFLE AND PRIMING CAPS

The mixture strength at any point on the throttle curve is governed by purely mechanical means, there being no venturi or special jet arrangement. The jet depression is obtained by restricting the air flow at what approximates to a sharp-edged orifice; consequently the loss through the carbureter is very high compared with a carbureter using a venturi tube to get the jet depression.

Contrary to usual practice, the jet depression actually increases on throttling down, the depression being about four times as great at half throttle as at full throttle.

Control Adjustment—When running slowly, the throttle is slightly open, the supplementary air port closed, and the air shutter practically closed; in this position the small or pilot jet only is open. On opening the throttle, the supplementary air port commences to open in conjunction with the throttle opening. The main air shutter automatically opens in propor-

* Concluded from the last issue.

tion, admitting more air, which passes directly across the top of the jets, and the jet area increases until the main jet orifice is fully open.

Owing to the interconnection of the control levers, there comes a point when the supplementary air port area increases

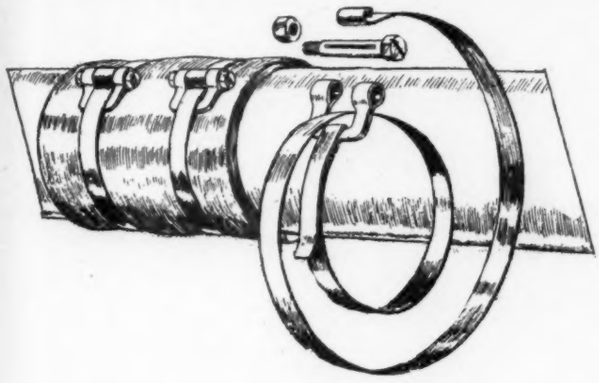


FIG. 29. STEEL BAND JOINT CLIP USED ON RUBBER CONNECTIONS OF INDUCTION PIPES AND WATER JOINTS

out of all proportion to the increase in the jet area, the latter reaching a limit, with no further increase by reason of the arrangement of the levers. This point represents the opening for maximum power at ground level. If the throttle is opened beyond this point, the air supply rapidly becomes out of proportion to the jet opening and petrol supply. By this arrangement a simple form of altitude control is provided.

The various positions for "slow running," "slow speed," "full speed" and "altitude" are marked on the body of the carbureter, and are indicated by a pointer attached to the throttle lever of the rear end carbureter. By means of these markings on the carbureter the correct settings of the throttle lever can be checked when the engine is installed in the machine.

The induction pipes are aluminum castings, and are of exceptionally neat design, being, as shown in Fig. 28, joined together in one straight pipe. A cast aluminum baffle plate drilled in the center with a 20 mm. hole is provided in the center of the two induction pipes between the front and rear three cylinders. This baffle is evidently fitted to equalize the gas supply to all cylinders.

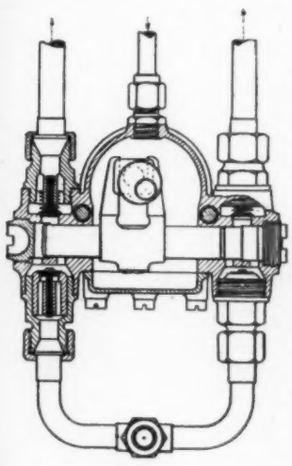


FIG. 30. CROSS-SECTION OF GASOLINE PUMP

Fig. 29 clearly shows the construction of the interesting type of band clip which is used for making the connections in the induction pipes, and also for most of the water joints on these engines. These clips are now extensively used on all enemy engines.

The clips are made of thin strips of annealed spring steel; these are wound twice round the rubber rings and fastened by small steel links and bolts. In starting to make this joint, the end of the steel band is first bent over the bottom bar of the connecting link and then wound twice round the rubber ring, the free end of the steel band passing through the center portion of the connecting link on the second winding. The end of the steel band is then fastened to the top end of the link by coiling the end several times round the small bolt in the head of the link, the end of the steel band being bent over for about 2 mm. and inserted into a slot cut in the bolt, so that by turning the bolt in the link the steel band is wound tightly round the ring joints, and, owing to the position and shape of the link, remains fixed.

Judging from tests made at the Royal Aircraft establishment, the carbureter seems satisfactory on throttle and power curves and atomization, but the resistance is very high and the weight excessive. The throttle curve is obtained by a complicated mechanical system which would need careful first adjustment and constant adjustment for wear. The air is taken in through the moving parts, and if any dust is present the mechanism is very liable to stick or to render the control very hard to operate.

Gasoline Supply System—Gasoline is supplied to the two carbureters by a small double-acting duplex gasoline pump, which is attached to the rear end of the bottom half of the oil base, and is driven at half engine speed directly off the rear end of the main oil pump spindle, the gasoline pump driving shaft being coupled to the oil pump spindle by a dog clutch. The installation of the gasoline pump is clearly shown in the general arrangement drawing of the engine, and the details of the gasoline supply system are shown in the diagrammatic drawing, Fig. 18. (Last issue.)

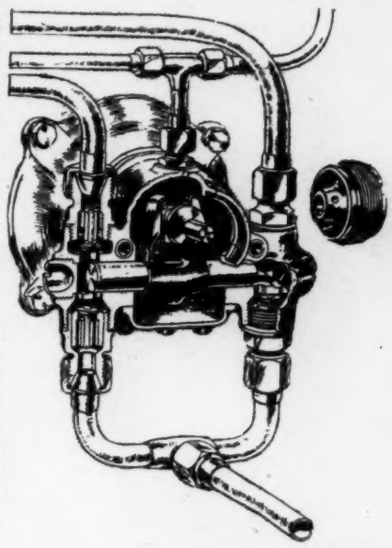


FIG. 31. SECTIONAL SKETCH OF GASOLINE PUMP

Regarding the installation of the gasoline supply system to the gasoline pump in the machine, it is assumed that the main which has always been fitted inside the gasoline tanks for regulating the supply through the gasoline pumps; but owing to the fact that the machines from which these new Maybach engines were taken are completely destroyed, no information regarding the construction and installation of the gasoline tanks is available.

Gasoline Pumps—The design of the compound gasoline pump is shown in the sectional drawing, Fig. 30, and also in the sectional perspective sketch, Fig. 31.

The gasoline pump consists of two opposed cylinders, in which a reciprocating plunger works, the ends of which operate as single acting pumps. The pump plunger carries a yoke fitted with a sliding bush, which forms the crank-pin bearing of the small pump crankshaft, driven, as already described, off the rear end of the oil pump spindle at half engine speed. The bore of the gasoline pump plunger is 15 mm and the stroke is 17 mm. The outer ends of the pump barrels are as shown, and are fitted with screwed plugs, which form compression chambers.

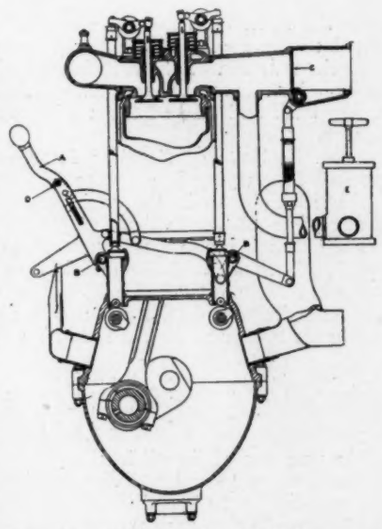


FIG. 32. DIAGRAMMATIC SECTION OF ENGINE, SHOWING FUNCTIONS OF STARTING MECHANISM

The small non-return suction valves are situated directly above and below the two compression chambers, and the two gasoline delivery valves are fitted above the compression chambers. The valves communicate with the compression chambers through small ports drilled in the pump barrel. Both the suction and delivery valves are of the poppet type, and each de-

livery valve is spring loaded by means of a small brass wire coil spring.

The valves are supported in guides drilled in the unions which form the valve boxes, and to which the gasoline delivery pipes from the gasoline tanks and to the carbureters are connected. The internal diameter of both these pipes is 10 mm.

It will be noticed that both the suction valves are fed by the same gasoline supply pipe as shown in the sketch.

The center portion of the gasoline pump body, which is a gun-metal casting, forms a small circular crank chamber for the pump plunger, and is fitted at the bottom with a detachable cover plate, which is secured by six set screws. The whole of the pump crank chamber is filled with oil under pressure from the main lubrication system, through an oil pipe connected to the centre of the pump body casting, and leading from the rear end of the detachable main oil lead pipe on the engine. By this means the efficient lubrication of the yoke and sliding bush and also of the seating of the pump plunger is assured.

R. A. E. Tests of Gasoline Pumps—Flow tests at three speeds with varying heads were taken; in order to represent working conditions in the engine, flow tests were also taken through jets similar to those employed on the engine.

The gasoline pump was run at three speeds, viz., 550, 800 and 1,275 r.p.m., and the outlet pipe was connected to the pump against a variable head from zero to 6 lb. per sq. in.

The maximum and minimum gasoline delivery at these speeds and heads are given in the following table:

Revs. per min.	Maximum flow. Zero head.	Minimum flow. 6 lb. head.
550	300 pints per hour	167 pints per hour
800	422 pints per hour	264 pints per hour
1,275	630 pints per hour	498 pints per hour

The pressure of the oil in the pump case during these tests varied between 15 and 20 lb. per sq. in., and the leakage of oil and gasoline past the end bearing of the pump spindle during one hour's run was approximately one pint.

Tests Through Engine Delivery Jets—In the engine the gasoline is delivered through restricting jets (shown in Fig. 27) into the constant-level tanks, which feed the jet chambers below, and are provided with overflows to the main petrol tank.

In the tests both outlets of the pump were connected by a V-piece with one delivery pipe, the end of which was closed by a plate 1/16 in. in thickness, having two .07 diameter jet holes drilled through.

The gasoline pump was run at the three speeds as in the former tests, and the following results recorded of delivery and head resistance:

R.P.M.	Head Resistance.	Pints per hour.
550	4.5 lb.	160 pints
800	9 lb.	218 pints
1,275	25 lb.	360 pints

Starting Gear—In the semi-diagrammatic cross-sectional drawing of the engine, Fig. 32, the working principles of this simple and distinctive starting mechanism are clearly shown. By the depression of the hand lever A on the induction side of the engine, all the tappets are lifted off their cams through the action of small lugs formed on the top of the tappets, which fit into slots cut in the tubular lay shafts BB. All the valves, both inlet and exhaust, are thus opened in the cylinder heads; and at the same time the hand lever A closes the shutter C in the exhaust manifold by the connection of levers shown in the drawing. The valves and exhaust shutter are then locked in this position by a peg, which is inserted in two holes D, which now coincide in the hand lever A. By the action of a large hand suction pump E in the pilot's seat, gas is then drawn into the combustion chambers through the inlet valves and induction pipe from the carburetors as indicated in the diagram. When the cylinders are charged the valves are returned to their normal positions by the withdrawal of the locking pin in the hand lever A, and simultaneously the free passage in the exhaust manifold is again opened by the shutter C. Ignition is then effected by means of a Bosch hand-starter magneto in the pilot's seat. It will be noticed that the exhaust shutter lever is provided with a spring-loaded tie rod to ensure a true seating for the shutter. In order to prevent the engine from being started until the hand lever has been released to its off position, the locking hole in the lever which takes the pin is made in such a way that only a special form of locking pin can be used. For this purpose the handle of the starting magneto is made easily detachable, and is used for the purpose of locking the hand lever A. It is thus practically impossible to cause ignition with the valves open and the exhaust passage closed, which, of course, would cause firing back into the carburetors, and probably also result in destroying the hand pump.

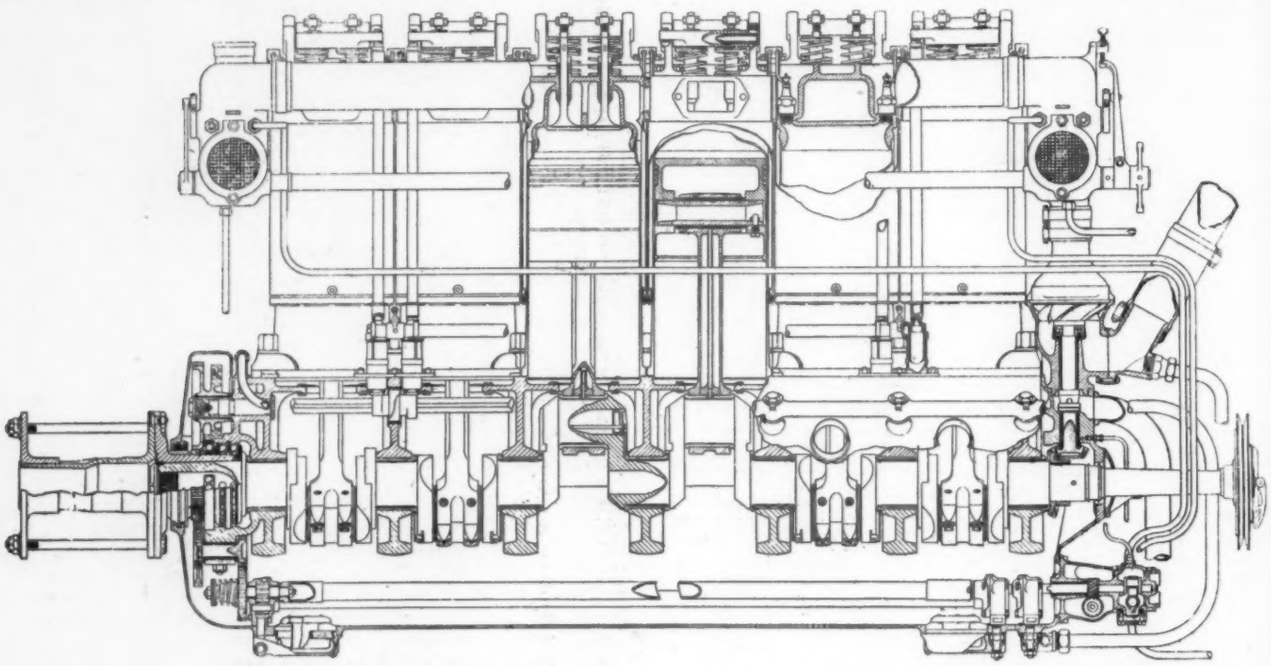


FIG. 33. SECTIONAL DRAWING OF THE 300 HP. MAYBACH ENGINE

Aeronautical Patents

ISSUED SEPT. 10, 1918

1,278,170—To John Koltko, Watertown, Conn. Smoke diffusing apparatus.
1,278,133—To John R. Gammeter, Akron, O., assignor to the B. F. Goodrich Co., New York City. Valve.
1,278,123—To John E. Dwyer, Springfield, Ohio. Return airship.
1,278,462—To John Harris, Lakewood, Ohio. Airplane.
1,278,247—To Anton Starosta, Erie, Pa. Airship.
1,278,179—To Walter F. Luff and Alfred Wm. Turner, Hansworth, Birmingham, England. Aircraft.

Light Alloys in Aircraft Construction

By F. W. Halliwell, A.M.I.A.E.

The following article is a sequel to the author's plea for a wider application of aluminum alloys to airplane construction, an excerpt of which appeared in the July 15, 1918, issue of AVIATION AND AERONAUTICAL ENGINEERING under the title Novel Ideas in Airplane Construction. In view of the numerous inquiries Mr. Halliwell's suggestions have elicited from our readers, the following elaboration of the case for the all-metal airplane, which is reprinted by courtesy of "Flight," seems of timely interest.

Aircraft of the present day are unique among similar productions of the engineering industry in perhaps more directions than one, but it is with regard to the materials employed that their insularity is most noticeable. The building of airplanes is essentially the business of an engineer, and timber, which is largely employed in airplane construction, is not usually associated with the work of an engineer, excepting for special fitments of more or less decorative nature, and for accessories which are added for comfort's sake, or to give a finish to the product. Therefore, after consideration, the fact that wood is universally used for the body and wings of airplanes, gives one to think rather furiously. It is obvious that there must be some decided advantage to be gained by its use, either from the designer's or the manufacturer's point of view, and upon carefully going into the manufacturing side of the problem, it will be seen that, for ease and speed of working, coupled with the facility with which scrap parts may be replaced, or alterations made, or even the whole design changed, without affecting the tools, there is no other material to compare with it. Also, by reason of the number of operations which can be performed on one kind of machine, which means that the wood-worker only requires two or three different types, where the metal-worker would probably require four or five, the capital outlay required to lay down, and the cost of maintenance of wood-working plants are much smaller than that necessary for the installation and upkeep of any factory of the same size, turning out metal products.

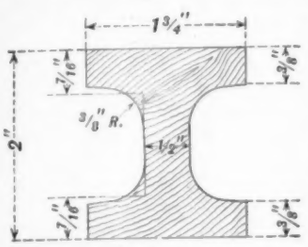


FIG. 1

Weight per ft. run, 0.425 lb.
Moment of inertia, 0.963 lb.

$$\text{Section modulus } Z = \frac{I}{y} = 0.963 \text{ lb.}$$

$$M = f \times Z = 1{,}200 \times 0.963$$
$$M = 1{,}157 \qquad f = 1{,}200$$

Undoubtedly the foregoing among other reasons have influenced manufacturers in favor of the present construction, while the absolute necessity of lightness has tied designers down to a very great extent. Another feature which must appear to the average engineer fresh from any other branch of industry, as a "nasty un-mechanical job," is the use of doped fabric. Here again designers have followed closely in the footsteps of their predecessors, endeavoring to improve existing methods rather than investigate any new line of progress. Taking a broad outlook and glancing back over engineering history it is easy to find analogous cases to that of the airplane. The most apparent, namely, that of the ship, is also that of the nearest allied branch of design, and it is possible to trace the development of a modern warship from canoes built of skins upon a wooden framework, through successive stages of timber constructions, noticing the gradual encroachment of metal work, until the present-day product is reached. There are many other similar cases which, if not so apparent, are equally significant. Are we to believe, then, that the airplane has reached its ultimate state so far as constructional design is concerned? It would hardly appear so.

Coming down to concrete facts, however, in order to see what may be gained, it is necessary to review the advantages and disadvantages of the present system of aircraft construction, and also that of any proposed design in metal. Assuming for the moment that it is possible to build a machine of some light alloy, which shall have the same strength/weight ratio as any existing model, what advantages can be claimed for it over and above those possessed by the more orthodox construction? From the designer's point of view any structure of metal is better than one of wood, because more accurate workmanship is possible and consequently the job is within closer limits, also there is less uncertainty about the ultimate strength of the material, which means that a smaller factor of safety can be used.

For instance, when a spar is made in spruce, a factor of safety of about ten is often employed. If the timber happens to be a faulty piece, this may be just enough to prevent the material being stressed beyond its elastic limit; if, however, it chances to be a good piece, free from defects, the factor of safety is much greater than is necessary and the spar much heavier than need be, yet this cannot be reduced because of the varying quality of the material.

Another point which commends the metal construction to the designer is the comparative ease with which it can be adapted to streamline shapes making for aerodynamical efficiency, also it lends itself well to quantity production, in which case the parts would be to a great extent interchangeable. Inspection would be simpler, due to more accurate workmanship, and less likelihood of hidden flaws in the material. Considering the question from the standpoint of the user, it is apparent that less maintenance work will be necessary, as there is no fabric to become "soggy," nor timber to warp or buckle in sympathy with the weather, and few, if any, bracing wires to adjust. The useful life of a metal machine would, under ordinary conditions, be much longer, as it would be much more impervious to the action of the elements, while its surface would not be affected by oil or gasoline as is the fabric of an ordinary airplane. Its non-inflammability would be a strong point in its favor; as long as the engine was screened and the gasoline and oil tanks were so placed that a bare flame could not effect a passage to them, any danger of fire in the air would be non-existent, while today, on certain types of machines, it is ever present.

Having enumerated all the points upon which the metal construction possesses a more or less distinct advantage, it will be remembered that so far we have only assumed that it is possible to build a machine with the same strength-weight ratio. It is now proposed to show that not only is this possible, but that it is quite likely that the present figures could be improved upon. Duralumin is the only metal possessing the necessary strength for weight, which up to the present is in anything like common use. It is in this direction that the metallurgist can be of considerable help to the aircraft industry. In an ordinary tractor airplane the majority of the more important members are stressed as beams. The wing spars are subjected to bending moments, and are generally regarded as continuous beams with the number of supports according to the number of interplane struts, while the body is usually considered as a cantilever. It would therefore seem reasonable to suppose that the material which as a beam is stronger for the same weight per foot run, can be built up into a machine which shall itself be lighter for the same strength than the orthodox construction.

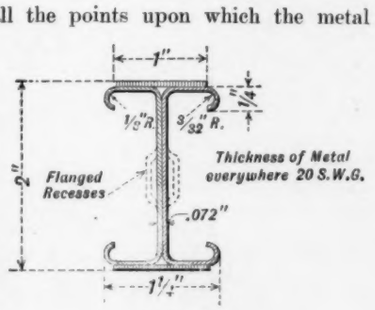


FIG. 2

Flanged recesses, three per ft. run. Weight per ft. run, 0.417 lb. Moment of inertia, 0.209 lb. Section modulus

$$Z = \frac{I}{y} = 0.209.$$

$$M = f \times Z = 9{,}333 \times 0.209$$
$$M = 1{,}940 \qquad f = 9{,}333$$

With this object in view it is proposed to compare two wing spar sections, one of Californian spruce and one of duralumin. Fig. 1 represents a section of typical proportions, the weight

per foot run in California spruce being 0.425 lb. Fig. 2 represents a section built up in duralumin to the same depth limit, viz., 2 in.; its weight per foot run is 0.417 lb., which is slightly less than that of the spruce section. For Fig. 1 f can be taken as 12,000, and using a factor of safety of 10, reduces to 1200. For Fig. 2, f can be taken as 56,000, and using a factor of safety of 6 (which is not too small), reduces to 9333. M for Fig. 1 comes out to 1157, and for Fig. 2, 1940. This shows a gain of 40 per cent of strength for the same weight, while the duralumin spar is actually not quite so heavy as the spruce one. The weight of the flanged recesses shown dotted has been taken into account, but they have not been considered when calculating the moment of inertia. The rivets have not been taken into account in either case; this is probably more than balanced by the extra weight of fittings, etc., and portions of the spar where the spindling is not carried through in the case of the spruce spar. This construction of duralumin spar, herewith shown, is patented.

Having proved that metal is superior as far as strength for weight goes, and taking into account the advantages outlined above, it would seem that the case for the all-metal machine is well founded from the point of view of the designer, and also from that of the user. We have now to consider the question of comparative cost of, and incidentally the speed of production.

The operations required to produce the longitudinals, such as planing up and spindling, would probably be just about balanced by the operations necessary for rolling the longitudinal members of a metal body, and though body struts are quickly and easily made, we must also consider the relatively large number of them, and their accompanying wires, turnbuckles, shackles, etc.; against all these we probably have the production of a few flanged transverse members in most cases blanked out in one operation. Some time would no doubt be gained here by the metal construction. In the case of the orthodox machines by far the biggest proportion of time and labor is spent in assembling the sides of, and erecting, and trueing the body itself. The body of an average up-to-date machine of the scout type can be completed in approximately 550 to 660 man hours. These may be divided up somewhat as follows:

	Man hours.
1. Assembling sides alone (in jig)	60 to 80
2. Erecting sides	130 to 160
3. Fitting and trueing engine bearers or plates	60 to 100
4. Fitting and trueing undercarriage	12 to 15
5. Fitting fairing, decking, etc.	80 to 90
6. Installation of tanks and pressure and fuel system	Approx. 40
7. Installation of engine, guns and gun gear	" 80
8. Assembling and fitting controls and control cables	" 30
9. Installation of water pipes (if water cooled) and radiators	" 40
10. Painting and finishing and fitting cowling	20 to 25

From the above figures it may be seen that approximately 50 per cent of the total man hours are spent in erecting and trueing the body itself. Considering the metal body against these 330 man hours, we should have to put the time for erecting the transverse members in the longitudinals and fitting the shell complete and riveting up.

Assuming a fair output per week, this would probably amount to 100 man hours in the best cases, and not more than 200 in the worst. This, of course, is only an estimated figure, but it would seem obvious that the metal body would score heavily on erection times. With regard to times for installing engine, gasoline tank, piping, etc., it is probable that these would work out about the same for each construction. As in the metal machine there is no fabric, more time and money would be saved here by the non-existence of the dope shop.

The point might be raised that press tools, dies, etc., would prove a large item in the costs, but actually the number of dies and punches involved would probably be less than for the average present-day machine, with its numberless small body clips and fittings, very often all of different sizes and shapes. The shell itself and similar parts could in most cases be made in wooden dies, while the longitudinals would be rolled.

Summing up the case for production, it is very difficult to compare with accuracy the relative costs of the two constructions, as all figures for an entirely new type of machine can of necessity only be estimated, but with the saving which could be effected on body erection, and the fact that the "trueing" of the body and doping would no longer be necessary, it would seem reasonable to regard the all-metal machine favorably from a manufacturing point of view as well.

National Physical Laboratory Report, 1917-18

The following references to aeronautical work at the National Physical Laboratory of Great Britain occur in the report for the year 1917-18:

Research Work—During the past year the laboratory has been asked by the Ministry of Munitions to undertake the manufacture of a certain class of gauges and to extend largely the provision for the testing of glass vessels for chemical work. For these two objects new buildings are required and are being provided. The laboratory has also been required by the Air Ministry to extend the accommodation for aeronautics work, especially by the provision of additional large air channels, and new buildings for this purpose have been commenced. Two 7-ft. channels are at present available for aeronautics research, in addition to two 4-ft. and one 3-ft. channel. During recent years the use of the larger channels, with higher wind speeds, has been found to be of increasing importance, and in view of the great number of investigations demanding attention, the Air Ministry has arranged for the provision of two additional channels.

Work of Sub-Divisions—In the Electrotechnics Division investigations have been in progress with regard to various insulating materials, undertaken for the Institution of Electrical Engineers, and much time has been devoted to research on magnetos for the Engine Sub-Committee of the Advisory Committee for Aeronautics. Work on searchlight carbons is being carried out for the Admiralty and the War Office. A large amount of work has again been done in connection with height finders, and advice and assistance have been directly given, both in France and in the course of inspection of instruments installed in this country.

In the Heat Division a considerable number of conductivity and other tests have been carried out for the Light Alloys Sub-Committee of the Advisory Committee for Aeronautics, and an interesting series of tests has been made of pyrometer tubes of British manufacture.

In the Engineering Department a large number of special investigations have been completed for the Air Ministry and the Advisory Committee for Aeronautics.

In the Aerodynamics Department changes have taken place on the staff. Mr. Bairstow left the Laboratory early in the year to take up work under the Air Board (now the Air Ministry), and Dr. Stanton has since resumed control of the Division. Mr. Relf holds the rank of senior assistant, and Mr. Pannell and Mr. Fage have recently received promotion to that rank. The volume of work to be dealt with still continues to increase. The necessity of employing large models for certain classes of work has led to a very great demand for the use of the larger channels. The need of additional large channels has become urgent, and as already mentioned, two are being provided in the new buildings.

There have been some additions to the main equipment during the year. The balances and subsidiary apparatus are constantly being improved in small details, as suggested by experience. A new airscrew balance for use in a 7-ft. tunnel is in hand, and a new apparatus for lift measurement has been constructed and is now in use. Modified apparatus for the measurement of rotary derivatives has also been devised and will be further developed.

A very large program of research has been carried out during the year. The work has been of the most varied character,

including experiments on models of all types of aircraft, with a number of investigations relating to special matters. Tests have been made on models of airplane wings, both monoplane and biplane models of complete airplanes, airship and kite balloon models, models of airscrews, with calculations relating to stability, strength of construction, bomb dropping, etc. A large amount of work has been done in connection with the design of wind channels. The research on eddy-motion has been continued.

In the Department of Metallurgy and Metallurgical Chemistry the work on light alloys has been the predominating feature. A large number of investigations have been carried out on the properties of various cast aluminum alloys, as required for the parts of aero-engines. Experiments on wrought alloys have also been continued. The enlargement of the foundry has been a great assistance to progress with this work. In addition research work on steels has been proceeding, including investigations relative to boiler plates and to magnet steels.

In the Chemistry Division, the section dealing with fabrics, dopes, etc., for the Advisory Committee for Aeronautics has been very actively engaged throughout the year.

Engineering Department's Report—The Engineering Department reports having carried out hardness tests.

(*a*) Wear Test—As mentioned in last year's report this research is being extended to cover the effect of the wear caused by sliding abrasion, of variations in the relative velocity of the surfaces, and the pressure between them. Owing to the fact that for a considerable part of the year this machine has been required for urgent war work, the progress of the research has been appreciably delayed.

(*b*) Indentation Tests—The Brinell ball hardness test is that usually adopted for indicating the indentation hardness of a material. It is, however, open to the objection that it varies with the load and with the size of ball used, consequently a standard ball of 10 mm. diameter and a fixed load of 3,000 kg. are employed. It is not always possible to use this standard (*e.g.*, for very thin test pieces or very soft materials) and various methods are adopted of bringing results obtained with different balls and loads into line with those obtained by using the standard.

A series of experiments has been made with balls of different diameters in order to study the question, and it has been found that a hardness number can be obtained approximately independent of the ball diameter, by using the method suggested by Mr. Moore in a paper to the International Association for Testing Materials. This method is based on the conclusions of Meyer that, for the same material, the load divided by the area of the indentation is constant for the same angle of indentation. Moore suggested that the angle should be such that the diameter of indentation was half the diameter of the ball used.

For the same purposes an impact indentation test has advantages. The ball is in contact with the material for such a short time that it is a convenient test to use for high temperature hardness tests; also, the effect of time of application of load has not to be considered, it being well known that this affects the static hardness number and varies with different materials (the hardness number is constant for steel after about 15 to 30 seconds).

A series of tests have been made to coordinate previous work on the subject. Martel had used a conical point as an indenting tool, and Roos a 10 mm. ball. The former showed that with a point the energy of the blow was proportional to the volume of the indentation, and the latter that with a ball it was proportional to the square of the spherical area of the indentation. The tests made at the Laboratory confirm both experiments, the reason of the agreement being that whereas Martel's law of proportionality (to volume of indentation) applies to a ball as well as a conical point, the relationship given by Roos only applies to the ball for the small depths of indentation met with in the ordinary test work.

They have also carried out experiments on the effect of surface roughness on the heat transmitted from hot bodies to fluids flowing over them. The experiments with the apparatus described in last year's report, for determining the heat transmission to water from the internal surfaces of brass pipes smoothed and roughened, have been completed. The results showed that with the amount of roughening obtained, the heat transmission per unit surface per degree difference of temperature between metal and water for the smooth pipe could be increased in the ratio of about 2.5 to 1 for the same mean velocity of flow. It was obvious that if improvement of this order could be made in the surfaces of air-cooled engines and radiators, considerable economy in material could be effected in airplane engine design. To test this question a series of copper gills of the form and distribution commonly adopted in air-cooled engines were fixed to a cylinder of the engine, and set up in a wind channel. An electric current from a storage battery was then circulated through the gills, and from measurements of the current and resistance it was possible to obtain the temperature of the gills, and the heat dissipated. The gills were first tested in their ordinary smooth condition and were then roughened by means of corrugated steel dies.

In these experiments the roughening appeared to produce practically no effect on the heat transmission, this result indicating that the convection of momentum to the rough and smooth surfaces was approximately the same in each case. The precise reason for the apparent discrepancy between the two sets of observations is still under investigation.

A number of samples of steel have been submitted for tensile and compression tests at high temperatures ranging between 650 deg. C. and 950 deg. C. These were tested in the 10-ton Buckton vertical testing machine with a furnace consisting of a silica tube wound with platinum foil and capable of attaining a temperature of 1,000 deg. C. The temperature was measured by a platinum and platinum-iridium thermocouple, connected to a Paul millivoltmeter graduated to read from 0 deg. C. to 1,000 deg. C. by 10 deg. C., the couple being tied to the test piece so that the junction was approximately at the middle point. The tensile tests on six of the samples have been completed, the temperatures in each case approximating to 15 deg. C., 650 deg. C., 750 deg. C., 850 deg. C., 900 deg. C., and 950 deg. C., and the results obtained are very interesting.

Tests have also been made on half-size stream-line struts in order to compare the relative values of different kinds of wood for this purpose. Each strut was tested with an axial end load, and by the use of compound knife-edges, each end of the strut was free to take up any angular position when under test. The modulus of elasticity for each material was found by a bending test, and this value was used to calculate the critical load to cause indefinite bending according to the Euler theory for a simple strut.

The agreement between these critical loads calculated from the dimensions of the strut and the modulus of elasticity of the material and the observed loads causing failure was remarkably good, indicating that the end constraint obtained with the special device adopted was negligible.

English Universities to Teach Aeronautics

Several large sums of money have been given recently to leading English universities for the establishment of professorships in aeronautics. The University of London makes the announcement that it not only has accepted a gift, but proposed to start systematic work in the science of aeronautics as soon as a suitable appointment can be made to the chair.

Two years ago, when some of the oldest colleges and universities, like Oxford and Cambridge, were taken over in connection with the training of air pilots there was some misgiving in educational circles over this invasion of scholastic haunts, but since that time several leading educators have issued statements declaring that this invasion is "no more than a symbol of the rennaissance of learning and an adaptation of old learning to modern needs."

Although universities still maintain that the old colleges will be restored to their traditional use after the war, it appears evidence that the influence of aeronautical work now being done there will have a lasting effect on higher education in England. Already some of the more modern universities are discussing the practicability of offering a special degree in aeronautics in connection with special courses of teaching. These courses would be aimed at combining the work of experimentalists and theorists with that of practical fliers in the development of what is destined to become a big factor in industrial and national life.

Digest of the Foreign Aeronautical Press

Aeronautics, Oct. 9, 1918

The Strain and Stress of Flying. By Lieut. E. G. Manuel, R.A.F.—The strain of ordinary straightforward aerodrome flying, to the qualified pilot, consists chiefly in the liability to engine failure and the fear of crashing the machine on landing. In cross-country flying the strain is much greater; there is still the fear of engine failure, which, in this case, may occur over unsuitable country, with the certainty of a crash. Added to this the pilot has to find his way, try to read a map, work his controls, and keep an eye on the compass. In addition he may

FARMAN TWO-SEATER RECONNOISSANCE MACHINE WITH 220-HP. LORRAINE-DIETRICH ENGINE

meet unfavorable weather, and be given the choice of flying at a dangerously low altitude or going above the clouds and frequently getting lost, with the added anxiety that in the event of engine failure he cannot see the kind of country he is over until at too low altitude to pick on suitable landing ground.

The strain on the single-seater pilot is greater than on the two-seater pilot, as, in addition, he has a sense of loneliness. Irrespective of the type of machine, this is accentuated at heights in the majority of cases. Inability to stand heights is not infrequently due as much to psychological causes as to distress caused by insufficient oxygen.

One of the greatest strains on the pilot's nerves is when he sees one of his friends go down in flames, or, after arriving at the mess, he learns that so-and-so is missing. When this occurs with monotonous regularity it is very hard for the pilot to maintain his mental equilibrium. There is no branch of the service where losses are more keenly felt.

In long reconnaissance and bombing raids the chief anxiety is again one of engine failure and forced landing in enemy country, or getting detached from one's flight for some reason or other and becoming a comparatively easy prey to a group of hostile machines.

Probably the strain that tells most on the pilot is the constant anti-aircraft fire. He begins by disliking it intensely, has a period of complete indifference, followed by an obsession that he has escaped so long that he must be hit at any moment. Though this strain is felt by all pilots, whatever their duties, it is most marked in those on fighting machines, two-seaters or scouts. While the chance of a fight is eagerly welcomed as a distraction, it frequently happens that no combatants appear for long periods, and the pilots are left without any occupation to distract them from the constant anti-aircraft fire, which, from the fact that the machines are constantly passing and repassing the same strip of territory, allows unrivalled opportunity for good shooting.

During the last few months great attention has been paid to low flying (at 500 ft. or less), attacking the enemy with machine-gun fire in his trenches, while marching along the roads, in rest billets behind the line, etc. The strain of this kind of flying is great, as the machine is subjected to a tremendous amount of machine-gun fire, and when working in conjunction with an infantry attack is continually in, or very near, the barrage fire put up by the artillery. A hit that might only temporarily disable the airplane and give the pilot time to recover from it flying at a height is probably fatal when so near the ground.

Flight, Sept. 19, 1918

Germany's Fright of Aerial Propaganda—From a frontier correspondent the Amsterdam *Telegraaf* learns that the German commander at Ghent, Major von Blücher, has issued a proclamation to the inhabitants threatening them with a fine of £150 or one year's imprisonment, or both, if they fail to hand over immediately any literature dropped by airmen in Belgium. The correspondent adds:

I have seen a copy of a newspaper printed in London and entitled *Le Courrier de l'Air*. With a small piece of lead attached, it was thrown out of some flying machine, as the inscription "By Balloon" indicated. The newspaper contained war news, a review of the French offensives, and of the situation in Germany.

Problem of Boxing and Shipping Planes

The shipping of American built airplanes by rail to the seaboard and thence by ships overseas has become a problem. It involves the transportation of an immense aggregate weight and demands a great amount of space. Planes and their accessories are so delicately constructed that they require careful packing and strong boxing, and the boxes must be so built that they may be taken apart on the field without injuring the units and used for re-packing like a wardrobe trunk.

Studies of the plane-boxing and shipping problems by the Bureau of Aircraft Production, have resulted in a material saving of lumber and shipping space. In shipping the American De Haviland bombing planes alone, for example, 644 cu. ft. of space have been saved over former methods, for every plane sent. This amounts to a cost saving of about $3,864 per plane, figuring on shipping space at $6 per cu. ft. About 1,000 board feet of lumber have also been saved in boxing by the Packing and Boxing Section.

In the case of the De Haviland battle planes, nine packing boxes are required to ship four complete machines. They are packed as described above. The gross weight of four planes is a little over 11,000 lb. and when packed the total weight is estimated a little under 27,000 lb. Four of the nine boxes contain front sections of the body. One of them contains four rear sections, two contain two sets of wings each; one, four sets of rear controls, and one, four sets of ailerons. The total space required for four airplanes so crated is 3,547 cu. ft. In addition to the parts actually required to complete the four airplanes, spare parts are also shipped. Two main wing boxes are sent with each unit shipment of four planes. This box contains besides the wings, with their fittings, axles, wing skids, landing gears, wiring plates, wheels, tires, struts and fittings. One aileron box is also sent with each shipment of four planes.

Shipments of spare parts for 100 De Haviland planes require 105 cases weighing approximately 164 tons. With every plane there are also shipped two Marlin synchronizing machine guns, operated by pilot, and two Lewis flexible machine guns operated by gunner; camera; attachments for a radio set, which is sent separately; heating and lighting equipment, bombing equipment and a great many instruments such as air pressure gauge, oil pressure gauge, aneroid barometer, clock, compass, map case, fire extinguisher, pilot's safety belt, gunner's safety belt, Very signaling pistol, etc.

All boxes are lined with water-proof paper and the tops covered with tarred felt fastened down on the sides and ends. All the joints are sealed with cement and the exteriors are given two coats of paint. Minute directions are given for packing the various parts of the airplanes. Braces and supports within the box are so constructed as to support the engine and body. Metal parts which might corrode are protected by a neutral slushing compound which is resistent to the effects of sea air and salt water. The instruments on the instrument board are heavily covered with a coating of paraffine, the more delicate instruments being removed and packed carefully in air-tight tin boxes.

News of the Fortnight

Hughes Report Made Public

The report of the aircraft production investigation conducted by former Justice Hughes has been made public. Limitation of space permits the presentation of only its salient points, which are the following:

1—The Liberty engine is the best in use by any of the belligerents.

2—Since the reorganization of the Aircraft Division "gratifying progress" has been made under the direction of John D. Ryan and William C. Potter.

3—Col. E. A. Deeds should be tried by court-martial under the articles of war for acting the "confidential adviser" of a business associate.

4—Criminal prosecution is urged against Leiut.-Col. Jesse G. Vincent, Lieut.-Col. George W. Mixter and Second Lieut. Samuel B. Vrooman, accused of owning stock in concerns in contractual relations with the Government.

5—Production took a big jump after having lagged for fifteen months, following the United States' entry into the war. Up to June 30 of this year only 529 DeHaviland service planes had been turned out and only 2390 Liberty engines. From June 30 to Oct. 11, 1821 DeHavilands and 7299 engines were produced.

6—Henry Ford's alleged sympathetic attitude toward enemy aliens and pro-Germans employed in his Detroit Liberty engine plant is criticized.

7—The "cost-plus" system was found unsatisfactory by the Government and by the manufacturers, much delay having been caused by complex auditing systems.

8—The flat assertion is made that initial delay in production was due to the incompetency of responsible Signal Corps officers.

In reading the report, the point that the public has not yet heard the defense should not be overlooked.

In transmitting the report to President Wilson, Attorney-General Gregory states that he is in substantial accord with the findings.

Standard Aircraft Club Election

On Oct. 1, at Elizabeth, N. J., there was held a meeting of a reorganization committee of the Standard Aircraft Club at the plant of the Standard Aircraft Corporation. Those present were: Wm. Tynan, G. M. Anderson, P. Hoffman, Mr. Ajax, J. M. Meirick, Wm. Knaus, Wm. Dornan, Mr. Hamblin, J. Koenig, T. Killea, C. Lindblum and R. A. Kettley.

The meeting was made necessary by the resignation of the president of the club. The following nominations for officers were unanimously made: President, Charles Lindblum; First Vice-President, Albert Johnson; Second Vice-President, Clifford Hamblin; Recording Secretary, Peter Hoffman; Treasurer, Thomas Killea; Trustees: G. M. Anderson, Wm. Knaus and Alex. Milne; Chairman of House Committee, Wm. Tynan.

The new club house will shortly be finished and the following committees were appointed to take charge of the opening event: Chairman Reception Committee, E. E. Pennewill; Chairman Arrangements Committee, G. M. Anderson; Chairman Music Committee, R. A. Kettley, and Chairman Decoration Committee, Wm. Dornan.

The Service Flag now flying over the Standard Aircraft plant in Elizabeth contains 286 stars, while the flag over the Plainfield plant of the company shows 64 service stars.

Watson on Hispano-Suiza Production

John W. Watson, president of the American Bronze Corp., has been appointed assistant chief of the Hispano-Suiza Engine Section of the Bureau of Aircraft Production under Budd D. Gray. The section has entire responsibility for Government engineering production and inspection activities, in connection with the manufacture of Hispano-Suiza engines, and involving the carrying out of an $80,000,000 program.

Following Watson's appointment, Matthew C. Dittman, vice-president and treasurer, was appointed general manager of the American Bronze, while E. G. Anderson, sales manager, was given charge of advertising. C. H. Baker, formerly auditor of the Timken Roller Bearing Co., has been given charge of the financial and accounting departments.

Aircraft Production Satisfactory

The most optimistic sort of reports in regard to aircraft construction, founded this time on actual production instead of on air and talk, have been furnished the Senate Military Affairs Committee at a meeting of the War Council, headed by Acting Secretary of War Benedict Crowell. This conference developed the following facts:

First—That about 2000 airplanes have been shipped to France, and that greater quantities are to go from now on.

Second—That four new types of airplane, some of them giving great promise of excellent results, have been developed recently.

Of the new types of airplane developed, that invented by Glenn L. Martin, of Cleveland, Ohio, occupies a prominent place. It is of the heavy bombing type and possesses great speed. It is claimed that the plane has developed 118 miles an hour.

Denial was made by Acting Secretary Crowell of stories that production of the Caproni or Handley Page heavy bombing planes had been ordered discontinued on account of the Glenn L. Martin airplane. The Caproni, it is learned, has passed all tests successfully so far, and if it meets additional tests it will be ordered in quantities.

A French expert, Captain Le Père, in the Fisher Body Company's factory at Detroit, has developed what is expected to be the best plane yet produced for the Liberty engine.

The Pomilio Brothers are conducting similar experiments at the Nordyke & Marmon factory in Indianapolis.

The fourth new type is designated as U. S. D. 9, formerly known as the De Haviland 9. This plane is to supersede the De Haviland 4, now being used by practically all the American aviators.

New York-Chicago Air Mail

Announcement was made by the Post Office Department on Oct. 24 that the proposed air mail route between New York City and Chicago will be inaugurated in December. No definite date for the opening of the new route has been set as yet, but it is placed somewhere between Dec. 1 and 15. The exact time will depend upon the receipt of the necessary equipment of new airplanes to operate the line.

In the meantime the work on the landing fields, emergency landing places, building of hangars, etc., has been begun, and is progressing satisfactorily.

The route will be laid out in three legs: the first from New York to Bellefonte, Pa., a distance of 215 miles, with an emergency station and machine midway at Lehighton; the second leg from Bellefonte to Cleveland, a distance of 215 miles, with an emergency station at Clarion, Pa., a distance of eighty-seven miles from Bellefonte, and the third leg from Cleveland to Chicago, a distance of 323 miles, with an intermediate mailing station at Bryan. The total length of the New York-Chicago aerial mail route will thus be 753 miles, as against 218 miles for the New York-Washington route.

The New York-Chicago route will be the last to be established while the war lasts.

New General Import License

Announcement is made by the War Trade Board of the issuance of a new general import license to be known as P. B. F. No. 27, effective Oct. 1. This license covers imports from the United Kingdom, France, Italy and their European or Mediterranean African possessions or protectorates.

Castor beans, iridium, platinum, mahogany logs and optical glass are among the commodities specifically excluded from the terms of this license.

A. W. Russel on War Credits Board

Acting Secretary of War Benedict Crowell has appointed Albert W. Russel a member of the War Credits Board to fill the vacancy caused by the resignation of Fernando P. Neal.

Mr. Russel has been connected with Mr. Crowell's office since January, 1918, and was formerly in the manufacturing business as president of the Russel Motor Axle Company and treasurer of the Russel Wheel & Foundry Company of Detroit.

Cross-Country Landing Fields

A chain of landing fields for the accomodation of air pilots is being slowly but surely established across the country. Beginning with the State of New York these landing places have already been located in Pennsylvania, Ohio, District of Columbia, Illinois, Georgia, Texas and California, and other States, in which they soon will be, include Arkansas, Mississippi, Alabama, New Mexico and Nebraska.

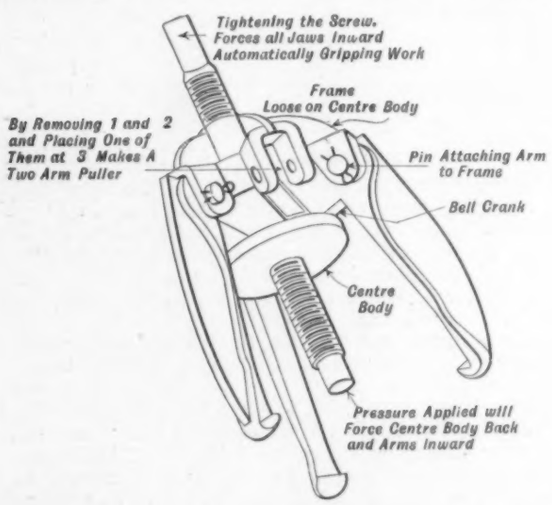
Today most of them are army fields, but the idea has aroused such public interest that many local business men's organizations are endeavoring to have other landing sites established in their respective cities. The proposition is that when the chain shall have been completed the fields will be about 100 miles apart and equipped to supply pilots not only with shelter and machine shop facilities, but also with oil, gas, maps, charts and barometrical and thermometrical ratings.

At the same time these fields will be so marked as to afford a well defined cross-country air route, and will eventually more than ever play an important part in the training of fliers.

Beach Junior Automatic Grip Puller

One of the most useful tools that have recently been developed for the prompt dissembling of airplane engines is the Beach Junior Automatic Grip Puller, which has been placed on the market by the Greb Co. of Boston, Mass.

The Beach Junior is designed to remove timing, magneto, and pump shaft gears and couplings, and is instantly adjustable to all types of engines. It has a positive grip, giving


Tightening the Screw, Forces all Jaws Inward Automatically Gripping Work
Frame Loose on Centre Body
By Removing 1 and 2 and Placing One of Them at 3 Makes A Two Arm Puller
Pin Attaching Arm to Frame
Bell Crank
Centre Body
Pressure Applied will Force Centre Body Back and Arms Inward

an even pull, and cannot unhook during operation. Its weight, complete with two sets of arms, one short, and one long, is only 3½ lb.; the 3½-in. arms, of drop forged steel, open to 4 in., while the 6-in. ones open to 7 in. The screw is of hardened tool steel; by tightening it the arms are forced inward, thus automatically gripping the work. Each set of arms has three arms, though the puller may be used with two or three arms, as desired. Extra jaws for special work may be fitted to the puller on order.

In view of the large number of special pullers which are in use in the aero-engine industry, each of which fits one kind of gear only, the value of the Beach Junior as a time and labor-saving device may readily be realized.

Discusses Radium Substitute

Dr. Richard B. Moore, of the United States Bureau of Mines, Golden, Colo., is reported to have announced the discovery of a substitute for radium. Dr. Moore has named the new product mesothorium. Among its uses is in the manufacture and illumination of airplane dials and compasses.

Miss Stinson in Air Mail Service

Miss Katherine Stinson, the well-known woman aviator, has been engaged by the Post Office Department in the capacity of aerial mail carrier.

Naval Airship in Long Flight

Washington had an opportunity to view one of the U. S. Navy's new twin engine dirigible balloons on Oct. 22, when it sailed over the city en route for the naval air station at Rockaway, N. Y.

This dirigible is known as the D-17 and was made by the Goodyear Tire and Rubber Co., of Akron, according to the plans and under the supervision of the Bureau of Construction and Repair.

The balloon left Akron at 1:10 a. m., C. T., and arrived at the Capital at 11:10 E. T., having made the flight in nine hours, or at the rate of approximately 35 m.p.h.

On board was a crew of six men, who had been detailed to make the trip. They were Major B. L. Smith, M. C.; Lieutenants R. A. D. Preston, D. T. Hood (j. g.), and W. L. Hamlin (j. g.), all of the U. S. N. R. F., and M. Roulette and James Royal, civilian mechanics.

Landing at Bolling Field to take on a fresh supply of fuel and resuming the flight from Washington at 1:17 p. m., the balloon reached its destination without mishap at 6:30 o'clock in the evening of the same day.

The total distance traveled was about 315 miles and the time was 13h. 13m.

Air Offices Will Not Move

For some time rumors have been current that the headquarters of the Air Service are to be moved from Washington to New York. The rumor included both the Division of Military Aeronautics and the Bureau of Aircraft Production.

An investigation developed a denial that anything of the kind is contemplated by the Division of Military Aeronautics. At the executive offices of the Bureau of Aircraft Production it was admitted last week that removal had been under consideration some time ago, but it was believed that the matter had now been dropped.

Delivery of Aircraft Bombs

Quantity production five months after the first deliveries were made was the achievement of American manufacturers of aerial projectiles. Official announcement to this effect was made in connection with an exhibition of aerial bombs and torpedoes at the Aberdeen, Md., proving ground.

First deliveries of the "demolition" and "fragmentation" bombs, the two types adopted for use by the Air Service, A. E. F., were made in April. Since then more than 3,000,000 of the projectiles have been turned over to the Government, almost a sufficient number, in the opinion of ordnance experts, to meet the demands of any aviation program now in contemplation.

New Aviation Camps

Among the new building projects undertaken by the Construction Division of the Army is the erection of a camp in connection with Cammack Field on Long Island, N. Y. This will accommodate four aero squadrons. In addition to accommodations for officers and men, fifteen hangars will be erected. The estimated cost is $99,605.

A similar camp will be erected at Babylon Field, Long Island.

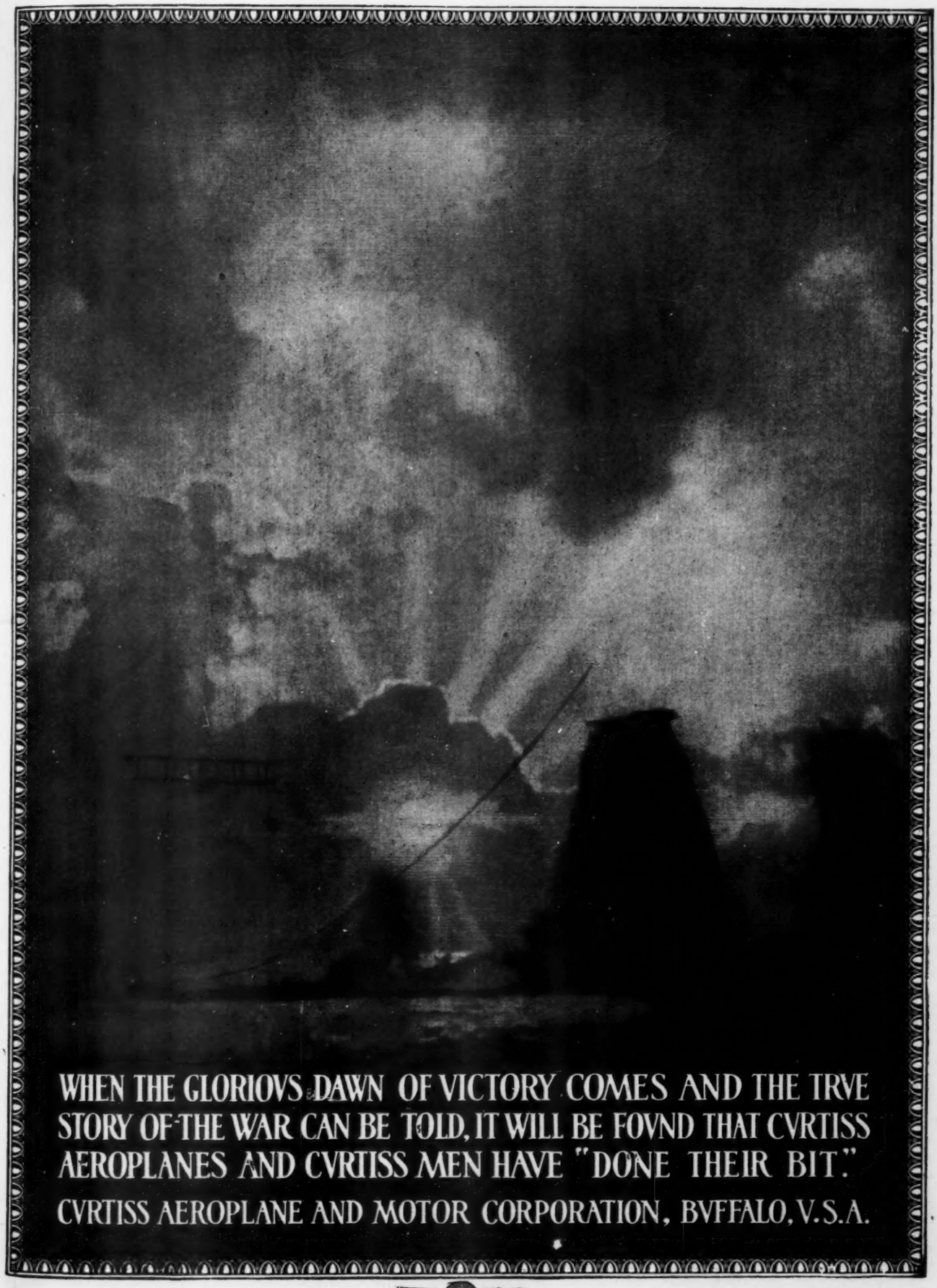
No Aero Show This Winter

At the meeting of the Directors of the Manufacturers' Aircraft Association held recently, the following resolution was passed:

Resolved: That by reason of the war emergency and the desire on the part of all members of this Association to devote their entire energies to meeting the demands of the Government for airplanes, that this Association will not hold its contemplated annual show during the coming season.

Duesenberg Washington Office

The Duesenberg Motors Corp. has announced the establishment of a Washington office in the Munsey Building in order to facilitate their intercourse with the various Government departments, as their entire facilities are being devoted to the execution of Government contracts. N. G. Rost, General Sales Manager, formerly located at No. 120 Broadway, New York, is making his headquarters at the Washington office for the duration of the war.


WHEN THE GLORIOVS DAWN OF VICTORY COMES AND THE TRVE
STORY OF THE WAR CAN BE TOLD, IT WILL BE FOVND THAT CVRTISS
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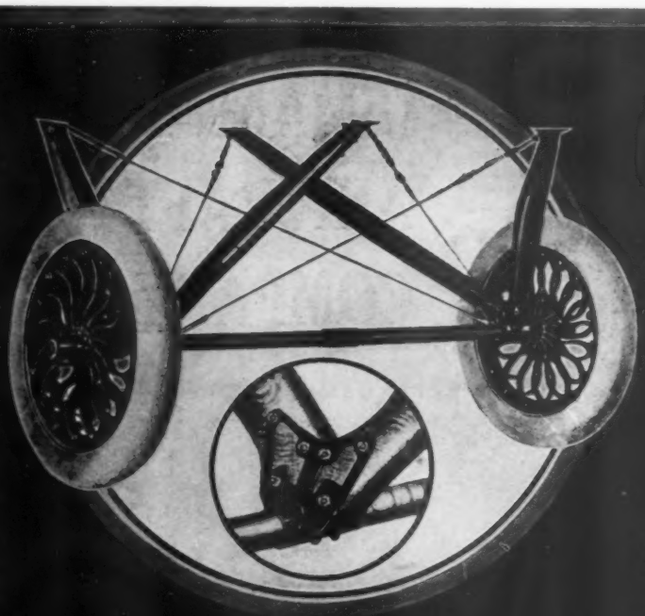

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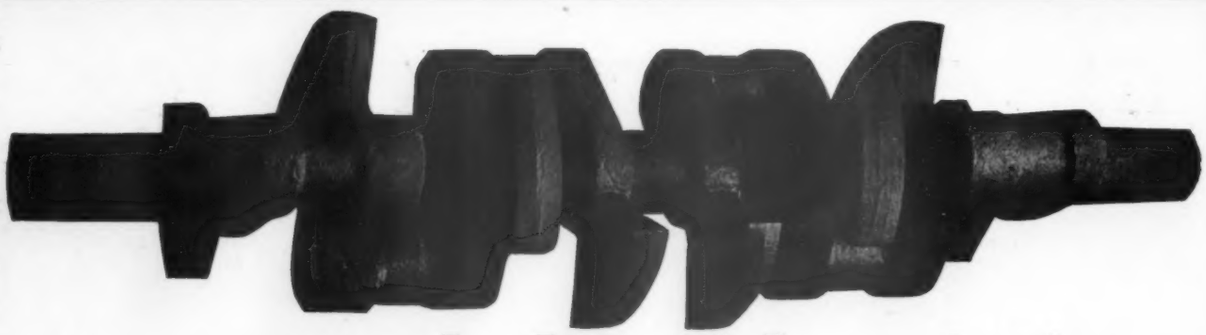

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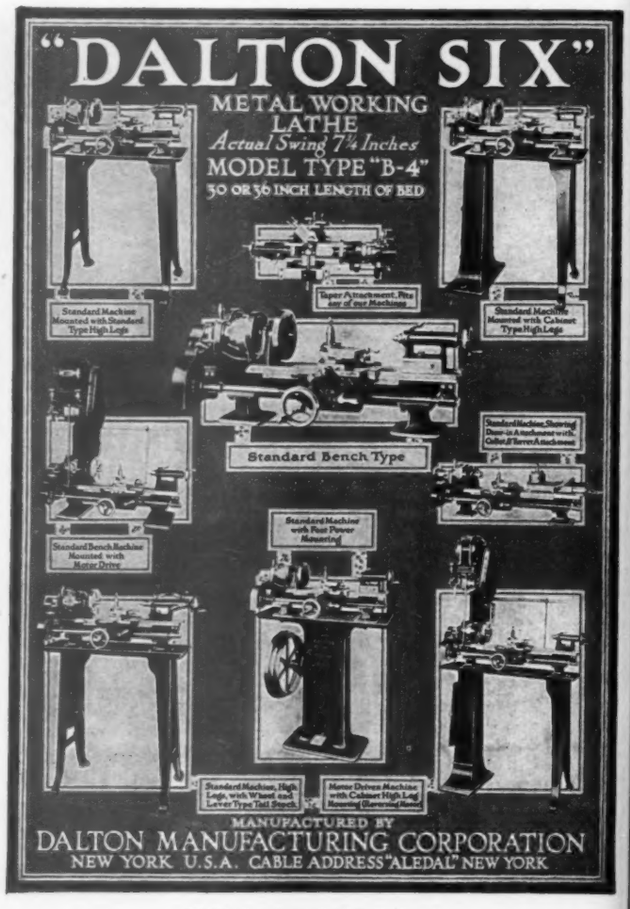

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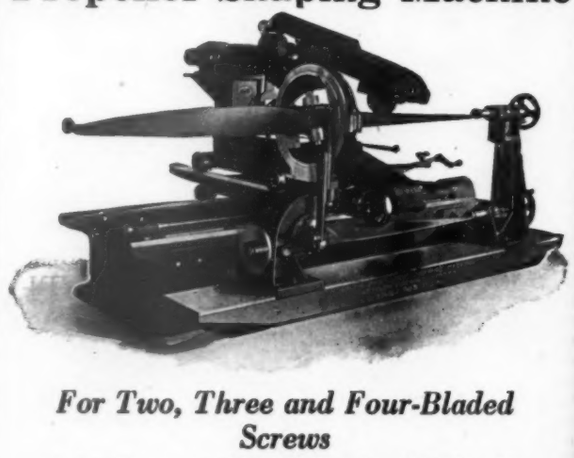

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Names of Advertisers in this issue are printed in capitals.
See Index to Advertisers on page 525

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International Aeronautical Instrument Corp.
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King, Julius, Optical Co.
The Moto-Meter Co.
National Gauge & Equipment Co.
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Peirce, Sam'l S., Aeroplane Corp.
RUBAY CO.
St. Louis Aircraft Co.
Smith, Kyle, Aircraft Co.
Sperry, Lawrence, Aircraft Co.
Springfield Airplane Co.
STANDARD AIRCRAFT CORP.
Sturtevant Aeroplane Co.
THOMAS-MORSE AIRCRAFT CORP.
The Willys-Morrow Co.
WITTEMANN-LEWIS AIRCRAFT CO.
Whittemore-Hamm Co.
WRIGHT-MARTIN AIRCRAFT CORP.

AIRPLANE ENGINES

Aeromarine Plane and Motor Co.
Ashmusen Mfg. Co.
Continental Motors Co.
CURTISS AEROPLANE & MOTOR CORP.
Detroit Gas Turbine Corp.
DUESENBERG MOTOR CORP.
General Ordnance Co.
General Vehicle Co.
Gyro Motor Co.
HALL-SCOTT MOTOR CAR CO.
Kemp Machine Works.
Kessler Motor Co.
Knox Motors Co.
Nordyke & Marmon.
Packard Motor Co.
Roberts Motor Mfg. Co.
Rolls-Royce, Ltd.
Springfield Motors Co.
Sterling Engine Co.
Sturtevant, B. F., Co.
Trego Motors Corp.
THOMAS - MORSE AIRCRAFT CORP.
UNION GAS ENGINE CO.
Van Blerck Motor Co.
Willys-Overland Co.
WISCONSIN MOTOR MFG. CO.
World's Motor Co.
WRIGHT-MARTIN AIRCRAFT CORP.

AIRPLANE PARTS

Aircraft Parts Mfg. Co.
American Body Co.
Astoria Veneer Mill & Dock Co.
BARCALO MFG. CO.
BUFFALO PRESSED STEEL CO.
Century Telephone Construction Co.
Chicago Aeronautical Supply Co.
Dayton Metal Products Co.
ERIE SPECIALTY CO.
General Aluminum & Brass Mfg. Co.
GENERAL BAKELITE CO.
Holbrook Co.
KAWNEER MFG. CO.
Levett, Walker M., Co.
New Jersey Veneer Co.
Pressed & Welded Steel Products Co.
Rogers Construction Co.
Standard Parts Co.
Welch Mfg. Co.
Whittemore-Hamm Co.
WIDMAN, J. C., & CO.
Willys-Morrow Co.
Wilson Cabinet Co.

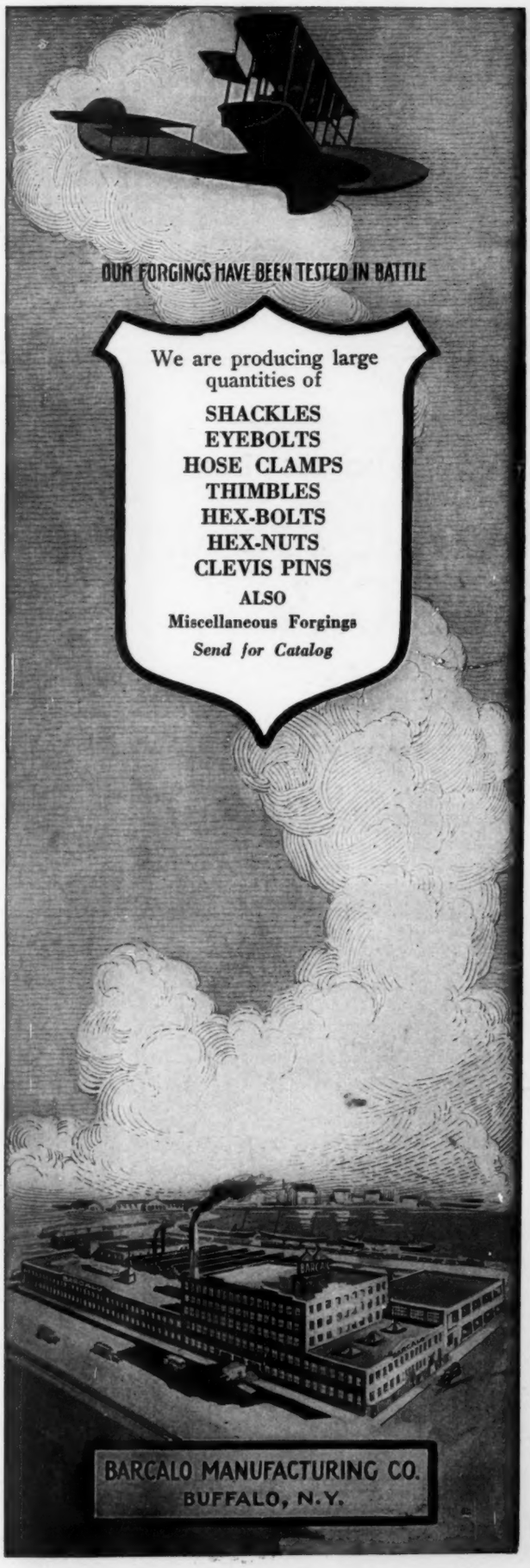
ALUMINUM

Acieral Co. of America
ALUMINUM CASTINGS CO.
ALUMINUM CO. OF AMERICA
American Metal Co., Ltd.
General Aluminum & Brass Mfg. Co.
Levett, Walker M., Co.
Leygrand & Co.
McAdamite-Aluminum Co.
So-Luminum Mfg. & Eng. Co. (Solder)
STIMPSON, EDWIN B., CO.
United Smelting & Aluminum Co.

AVIATION SCHOOLS

EAGLE AVIATION SCHOOL
Michigan State Auto School
Morris-Bud Airplane School
Penn. State School of Aero-Mechanics
West Side Y. M. C. A.
Whittemore-Hamm Co.

(*Continued on page 513*)



The maker who uses the

Buffalo Pressed Steel Co.'s Products

is in *right*

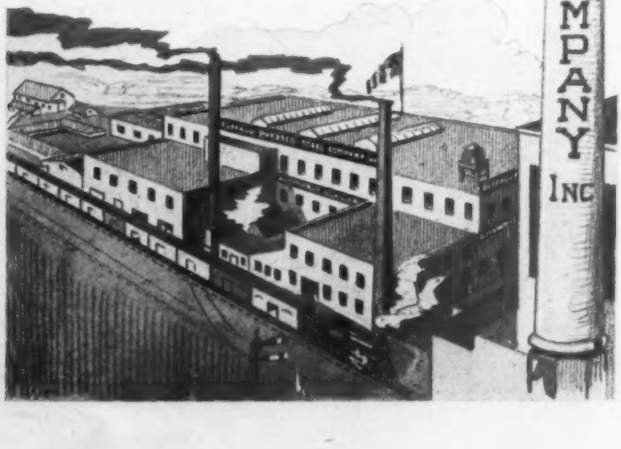
He has nothing to fear on the score of either service or workmanship—on the contrary, he has cause for gratification in both.

The service of the Buffalo Pressed Steel Company is attested by the fact of their large completely equipped plant which can turn out the products wanted in a very short time.

The workmanship of the Buffalo Pressed Steel Company's products is attested by the products themselves which are the acme of perfection in quality, design and finish.

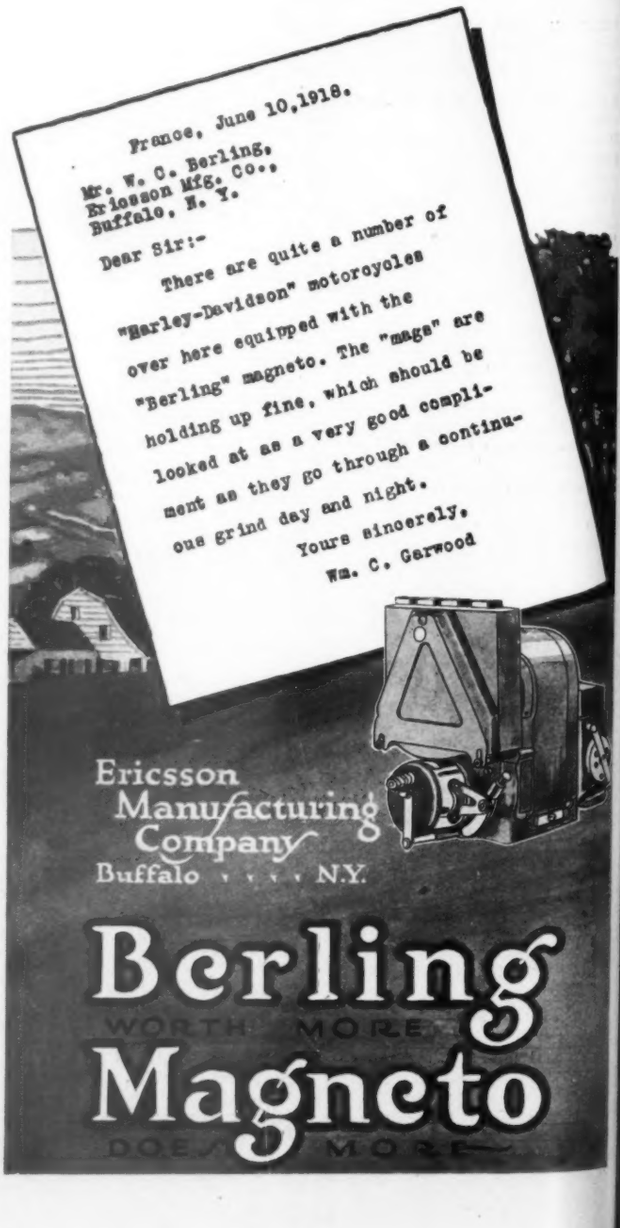
And the maker who uses the Buffalo Pressed Steel Company's products has mastered in at least one branch of his expenditures, the golden art of getting more than an average equivalent for what he spends.

Write us your specifications for Aeroplane Parts, etc., Buffalo Pressed Steel Company, Inc., Buffalo, N. Y.



BUFFALO PRESSED STEEL COMPANY INC

France gives trying test to Berling


France, June 10,1918.
Mr. W. C. Berling,
Ericsson Mfg. Co.,
Buffalo, N. Y.
Dear Sir:-
There are quite a number of
"Harley-Davidson" motorcycles
over here equipped with the
"Berling" magneto. The "mags" are
holding up fine, which should be
looked at as a very good compli-
ment as they go through a continu-
ous grind day and night.
Yours sincerely,
Wm. C. Garwood

Ericsson Manufacturing Company
Buffalo . . . . N.Y.

Berling Magneto

WORTH MORE
DOES MORE

Aeronautical Trade Directory—*Continued*

BALL BEARINGS
THE FAFNIR BEARING CO.
Gurney Ball Bearing Co.
HESS-BRIGHT MFG. CO.
NEW DEPARTURE MFG. CO.
NORMA COMPANY OF AMERICA
S. K. F. BALL BEARING CO.
U. S. Ball Bearing Mfg. Co.

BALLOONS: DIRIGIBLES
Burdette Oxygen Co.
Connecticut Aircraft Co.
Custer Specialty Co. (Stato-scope)
Gas Engineering Co. (Gas Plants)
GOODYEAR TIRE AND RUBBER CO.
United States Rubber Co.

BAROGRAPHS AND BAROMETERS
Green, Henry J.
International Aeronautical Instrument Corp.
Sussfield & Lorch
TAYLOR INSTRUMENT COMPANIES

BEARING METALS
ALUMINUM CASTINGS CO.
American Bronze Corp.
FAHRIG METAL CO.
General Aluminum & Brass Mfg. Co.
Levett, Walker M., Co.
Magnolia Metal Co.

BUSHINGS
ALUMINUM CASTINGS CO.
American Bronze Corp.
Bound Brook Oil-less Bearing Co.

CARBURETORS
H. & N. Mfg. Co.
Master Carburetor Co.
Miller Carburetor Co.
Stromberg Motor Devices Co.
Wheeler & Schebler
ZENITH CARBURETOR CO.

CLOCKS AND WATCHES
Chelsea Clock Co.
Depollier, J., & Son
Hamilton Watch Co.
Ingersoll, Robert H., & Bros.
Waltham Watch Co.

CLOTHING
Abercrombie & Fitch
Cross, Mark
N. Y. Sporting Goods Co.
Rainwear Co.
Rogers, Peet & Co.
Sanders Company
Spalding, A. G., & Bros.

COMPASSES
Sperry Gyroscope Co.
Star Compass Co.
TAYLOR INSTRUMENT COMPANIES

DOPE AND VARNISH
Adams & Elting Co.
American Emaillite Co.
Brooklyn Varnish Mfg. Co.
Certus Cold Glue Co.
Chemical Products Co.
Conover, The C. E., Co.
Du Pont Chemical Works
Flexible Compound Co.
Harland, Wm., & Son
Howe Varnish Co.
Lucas, John, Company
Masury, John W., & Son
Perry-Austen Company
PRATT & LAMBERT
SHERWIN-WILLIAMS CO.
Smith, Edward, & Co.
Standard Varnish Works
Valentine & Company
Weeks & Co.

DRIFT INDICATOR
Sperry Gyroscope Co.

DRY KILNS
Cutler Dry Kiln Co.
Drying Systems, Inc.
GRAND RAPIDS VENEER WORKS

DYNAMOMETER
Sprague Electric Works

ENGINE PARTS
Allegheny Forging Co.
ALUMINUM CASTINGS CO.
Anderson Forge & Machine Co.
BARCALO MFG. CO.
Brooks Machine Co.
BUFFALO PRESSED STEEL CO.
Burd High Compression Ring Co.
Crosby Steam Gage & Valve Co.
Dallet, Thos. H., Co.
DOEHLER DIE CASTING CO.
ERIE SPECIALTY CO.
Fibre Finishing Co.
General Aluminum & Brass Mfg. Co.
Gifford, Leland, Co.
Gill, P. H., & Sons
Hayes Mfg. Co.
Hydraulic Pressed Steel Co.
Levett, Walker M., Co.
Meisel Press Mfg. Co.
PARK DROP FORGE CO.
Pressed & Welded Steel Products Co.
Standard Parts Co.
STIMPSON, EDWIN B., CO.
Taft-Peirce Mfg. Co.
Tioga Steel & Iron Co.
Williams, J. H., & Co.
Whitman & Barnes Mfg. Co.
WYMAN-GORDON CO.

ENGINEERING
Automotive Engineering Co.
Ordnance Engineering Co.
White, J. G., Engineering Corp.

FABRICS
Courtral Mfg. Co.
Hutchinson, Scott Co.
Lamb, Finlay & Co.
McBratney, Robt., & Co.
Whitman, Clarence & Co.

FELT
Advance Felt Specialty & Cutting Co.
Booth Felt Co.
Western Felt Works

FIRE EXTINGUISHERS
Fyr-Fyter Co.
Johns-Manville, H. W., Co.
Pyrene Mfg. Co.

GAGES
Advance Felt Specialty & Cutting Co.
BOSTON AUTO GAUGE CO.
Crosby Steam Gauge & Valve Co.
FOXBORO CO., INC.
Greenfield Tap & Die Corp.
United States Gage Co.

GASKETS
Advance Felt Specialty & Cutting Co.
Booth Felt Co.
Fibre Finishing Co.

GLUE
Armour Glue Works
Baeder & Adamson
Certus Cold Glue Co.
FERDINAND, L. W., & CO.
Widman, J. C., Co.

(*Continued on page* 515)

A British Firm beats the Germans

THE MARKET PAGE
After the two torpedoes had descended from the machine it was loaded with dummy bombs in preparation for a flight. The now famous German flying officer Richthofen took the seat which the Kaiser had vacated, and two other officers also boarded the plane. With a terrific roar the two engines were started, and like a bird the aeroplane rose in the air. It climbed rapidly to about 10,000ft., and the Kaiser turned to General Höppner, saying.
"How is it that, at such a height and on so cold a morning, the lubricants do not freeze?"
"The British have discovered the secret which we have been seeking for months," replied the general. "Our great difficulty is now surmounted. D[illegible]
T[illegible]

Extract from "Life in Essen," Eye-Witness's Account, "Daily Mail," April, 1918.

KAISER (loq.): "How is it at such a height on so cold a morning the lubricants do not freeze?"

GEN. HÖPPNER: "The British have discovered the secret which we have been seeking for months."
Vide "Daily Mail," see above.

C.D.C.

THE SECRET

WAKEFIELD
Castrol 'R' MOTOR OIL
(Racing)
was the lubricant used.
Castrol "R" possesses the lowest cold test of any known Aero Engine Oil.

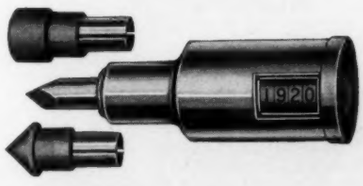
SBAC

C. C. WAKEFIELD & CO., Ltd.
(Sir Charles Wakefield, Bt., Governing Director)
WAKEFIELD HOUSE, CHEAPSIDE
LONDON, E.C.2. ENGLAND

Finding the R. P. M. of Airplane Motors

You have the opportunity to replace the time and labor waste of the preliminary block test by a handy application of the

Veeder
SPEED COUNTER



Simply hold the Veeder against revolving propeller shaft; apply slight pressure the moment you start timing; release pressure when minute is up. Clutch starts or stops recording mechanism instantly, giving accurate readings without need of stop-watch. Price, $3.00.

Veeder Counters for recording the production of machines are standard for all industrial purposes. Send for booklet.

The Veeder Mfg. Co.
56 Sargeant St., Hartford, Conn.

IN ACTUAL DAILY PERFORMANCE

In every branch of military service—Engineering Corps, Aviation Section, Quartermaster Corps, and general Patrol, Scout, and Dispatch duty—you will find the

Indian Motocycle
With Powerplus Motor

Greatest strength, endurance, speed, power, accessibility, and all-round dependability.
We will be pleased to arrange demonstrations of all Indian models for interested military officials.

Illustrated Indian Catalog and other descriptive literature sent anywhere on request

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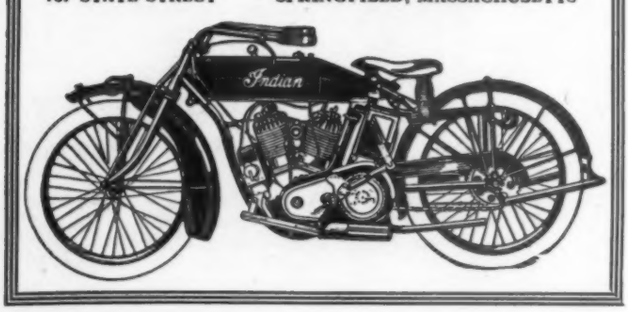
(Largest Motorcycle Manufacturers in the World)
767 STATE STREET SPRINGFIELD, MASSACHUSETTS



WEST WOODWORKING COMPANY

(Patent Pending)

Manufacturers of

Westmoore Propellers
Swesco Wing Beams
Waterproof Plywood Panels
Laminated Construction for All Parts

Highest Quality
Quantity Production
Prompt Shipments

Address:

WEST WOODWORKING COMPANY
308-324 N. Ada Street Chicago
Cable address "SWESCO"

Cabinet makers with over thirty years' successful business behind them

FUEL LEVEL GAGES

This cut shows our Model 51 Gage which is standard on practically all type of military training machines.

Other types of gages in large quantities are "doing their bit" as part of the equipment of English Government Warplanes.

SPECIAL TYPES DESIGNED FOR YOUR ESPECIAL NEEDS.

BOSTON AUTO GAGE CO.
8 WALTHAM STREET, BOSTON, MASS.

ROME AERONAUTICAL RADIATORS

Developed from years of experience in building all types of radiators.
They possess every feature and qualification necessary for a high grade product.

STRONG
EFFICIENT
DURABLE

Used on the best American flying machines.
Our engineering department is at your service.

Rome-Turney Radiator Company
Rome, N. Y., U. S. A.

Aeronautical Trade Directory—*Continued*

GOGGLES

Hardy, F. A., Co.
Meyrowitz, E. B.
STRAUSS & BUEGELEISEN
Strong, Kennard & Nutt
Triplex Safety Glass Corp.
Willson, T. A., & Co., Inc.

HANGARS

American Bridge Co.
Anchor Corrugating Construction Co.
Ashley Steel Bldg. Co.
Austin Co., The
Barney, John M.
Howell, Field & Goddard, Inc.
Keasby & Mattison
Milliken Brothers
Pruden, The C. D., Co.
Steel Fabricating Co., The
Virginia Bridge & Iron Co.

HOISTS

Yale & Towne Mfg. Co.

IGNITION

PHILIPS-BRINTON CO., THE

LIFE PRESERVERS

Robinson-Roders Co.
Universal Safety Mattress Co.

LUMBER

Alcock Co., John L.
American Balsa Corp.
Astoria Veneer Mills & Dock Co.
Chetham Lumber Co.
Delatour, J.
Dutton, A. C., Lumber Corp.
Ludlow, Israel
Mengel, C. C., & Bros. Co.
New Jersey Veneer Co.
Sheip & Vandergrift

LUMINOUS COMPOUND

COLD LIGHT MFG. CO.
Cummings, W. L., Chemical Co.
RADIUM DIAL CO.
RADIUM LUMINOUS MATERIAL CORP.

MACHINERY, METAL WORKING

DALTON MFG. CORP.
DEFIANCE MACHINE WORKS
FOX MACHINE CO.
Warner & Swasey Co.

MACHINERY, WOOD-WORKING

Curtis Machine Corp.
DEFIANCE MACHINE WORKS
Fay, J. A., & Egan Co.
FOX MACHINE CO.
Machinery Merchants, Inc.
MATTISON, C., MACHINE WORKS
Olney & Warrin
Pryibil, P., Machine Co.
YATES, P. B., MACHINE CO.

MAGNETOS

Berkshire Magneto Corp.
Bosch Magneto Co.
ERICSSON MFG. CO.
Remy Electric Co.
Splitdorf Electrical Co.

MANIFOLDS

AJAX AUTO & AERO SHEET METAL CO.
Pressed & Welded Steel Products Co.

METALS

Acieral Co. of America
American Bronze Corp.
American Vanadium Co.
Bethlehem Steel Co.
Betz-Pierce Co., The
BLUM, JULIUS & CO.
BUFFALO PRESSED STEEL CO.
Detroit Pressed Steel Co.
Federal Pressed Steel Co.
Garland Ventilator Co.
Gueder, Paeschke & Frey Co.
Kawneer Mfg. Co.
La Salle Steel Co.
Levett, Walker M., Co.
Rumford Metal Co.
SO-LUMINUM MFG. & ENG. CO.
Standard Alloys Co.
Steel Sales Corp.
Steel Products Co.
STIMPSON, EDWIN B., CO.
Wheeler, Frank H., & Son

MODEL AIRPLANES

Ideal Aeroplane Supply Co.
Wading River Mfg. Co.

MOTORCYCLES

Excelsior Motor Mfg. Supply Co.
HENDEE MFG. CO.
Harley-Davidson Co.
Militare Motor Vehicle Co. of America

OILS AND LUBRICANTS

BAKER CASTOR OIL CO.
Graphite Lubricant Co.
Gulf Refining Co.
Sheppard Ideal Oil Co.
Sun Co., The
Standard Oil Co.
Swan & Finch
Texas Co., The
Vacuum Oil Co.
WAKEFIELD, C. C., & CO., LTD.

PACKING

Advance Felt Specialty & Cutting Co.
Booth Felt Co.
Fibre Finishing Co.

PHOTOGRAPHY

Brock, Arthur, Jr.
Herbert & Huesgen Co.

PISTONS

ALUMINUM CASTINGS CO.
Levett, Walker M., Co.

PISTON RINGS

American Piston Ring Co.

PONTOONS

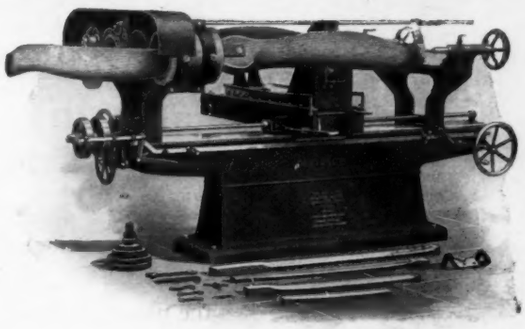
Niagara Boat Co.
PALMER-SIMPSON CO.
Welin Marine Equipment Co.

PROPELLERS

AMERICAN PROPELLER & MFG. CO.
American Sash & Door Co.
Avianto Mfg. Co.
Breitung & Co., Ltd.
C. M. O. Physical Laboratory
Doyle, W. A.
FLOTTORP MFG. CO.
Hartzell Walnut Propeller Co.
JACUZZI BROS.
Jamestown Propeller Co.
Lang Propeller Co. of America
Steves Sash & Door Co.
Reinforced Propeller & Insulating Co., The
United States Aero Propeller Co.
Washington Aeroplane Co.
WEST WOODWORKING CO.

(*Continued on page 517*)

THE DEFIANCE AUTOMATIC AIRPLANE PROPELLER LATHE



IT HAS GOVERNMENT AND MANUFACTURERS' ENDORSEMENTS

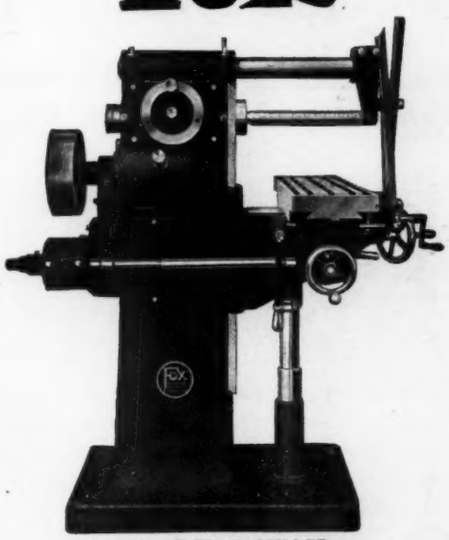
The proof of this lies in its use in England, in Italy, in Canada; its use in United States Government Arsenals, and fifteen of the leading propeller factories in America. Each machine in use releases from eight to ten skilled workmen for other duties. With one man operating a number of machines, the cost of working propeller blades close to size is reduced to a minimum. It automatically turns propeller blades of various sizes to any shape or pitch, and it will duplicate struts of irregular shape in facsimiles. Write for our circular which illustrates and describes this machine.

THE DEFIANCE MACHINE WORKS

DEFIANCE, OHIO, U. S. A.

NEW YORK *LONDON*

FOX



No. 2B PLAIN MILLER

Single Pulley Drive

12 changes to spindle speeds
6 changes to each spindle speed
No. 9 taper in spindle.
Table 8½ x 37"

Hardened machine steel gears throughout insure maximum driving power at all speeds.

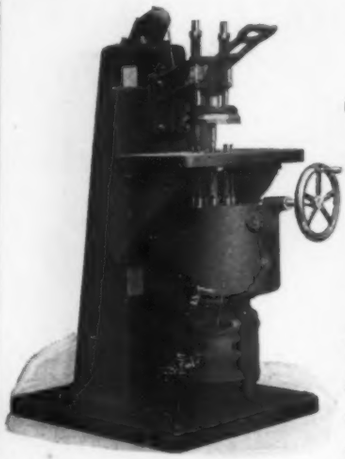
We also build Universal Millers, Dividing Heads, Vertical Attachments and Vises.

Write for Circular

THE FOX MACHINE COMPANY

1810 W. Gavson St., Jackson, Mich.

Formerly of Grand Rapids, Mich.



Yates

Type C-20 Propeller Boring Machine

A recently perfected machine for automatically boring the necessary holes in the modern aeroplane propeller hub in one operation. Extremely durable, compact, and efficient. Does absolutely accurate and uniform work. Specially designed so that no oil can get on and injure the stock. Either belt or direct motor drive.

Send today for complete details

P. B. Yates Machine Co.
BELOIT, WISCONSIN, U. S. A.

Elastic Aviation Cord

For Shock Absorbers on Airplanes

We originated and have developed this special heavy elastic cord for airplane shock absorbers.
We are the largest manufacturers in the world of Heavy Elastic Cord and owing to our factory capacity we can make prompt deliveries.
Samples on request

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FACTORY: STOUGHTON, MASS.
OFFICES
45 East 17th Street . . . . . New York
181 W. Lake Street . . . . . Chicago
82 St. Peter Street . . . . . Montreal, Canada

Fahrig Anti-Friction Metal

The Best Bearing Metal on the Market
A Necessity for Aeroplane Service

Fahrig Metal Quality has become a standard for reliability. We specialize in this one tin-copper alloy which has superior anti-friction qualities and great durability and is always uniform.

When you see a speed or distance record broken by Aeroplane, Racing Automobile, Truck or Tractor Motor, you will find that Fahrig Metal Bearings were in that motor.

FAHRIG METAL CO., 34 Commerce St., N. Y.

TURNBUCKLES

of the

Highest Quality

to Meet the Most
Exact Requirements

Standard Turnbuckle Company
CORRY, PA.

New York Office: Woolworth Building

Aeronautical Trade Directory—*Continued*

PYROMETERS
FOXBORO CO., INC., THE
Moto-Meter Co.
Shore Instrument & Mfg. Co.
TAYLOR INSTRUMENT COMPANIES

RADIATORS
AJAX AUTO & AERO SHEET METAL CO.
A-Z Co.
Bush Mfg. Co.
El Arco Radiators Co.
English & Mersick Co.
FLEXO MFG. CO.
Harrison Radiator Co.
Livingston Radiator Co.
McCord Mfg. Co.
ROME-TURNEY RADIATOR CO.
STANDARD ROLLER BEARING CO.

RIVETS
STIMPSON, EDWIN B., CO.

SCELEROSCOPE
Shore Instrument & Mfg. Co.

SHEET METAL FITTINGS
BLUM, JULIUS & CO.
Rogers Construction Co.

SHOCK ABSORBERS
DURAL RUBBER CORP.
General Rubber Goods Co.
Ohio Rubber Co.
Russell Mfg. Co.
WOOD, J. W., ELASTIC WEB CO.

SPARK PLUGS
Bosch Magneto Co.
Champion Ignition Co.
JOHNS-MANVILLE, H. W., CO.
Rajah Auto Supply Co.
Silvex Co., The
Splitdorf Electrical Co.

SPEED INDICATORS
FOXBORO CO., INC.
JOHNS-MANVILLE, H. W., CO.
Stewart-Warner Speedometer Corp.

STABILIZERS
Greene Aeronautical Co.
Martin Aerodynamic Stabilizer.
SPERRY GYROSCOPE CO.

STAMPINGS
BLUM, JULIUS & CO.
Enameling & Stamping Corp. of New York
LANSING STAMPING & TOOL CO.
Dewes Co., The A.
STIMPSON, EDWIN B., CO.

STARTERS
Bijur Motor Lighting Co.
Bosch Magneto Co.
Christensen Engineering Co., The
Dayton Engineering Laboratories Co.
MOTOR-COMPRESSOR CO.
Northeast Electric Co.
Remy Electric Co.
Wagner-Hoyt Electric Co.

TANKS
Janney, Steinmetz & Co.

THERMOMETERS
FOXBORO CO., INC., THE
Moto-Meter Co.
TAYLOR INSTRUMENT COMPANIES.

TIRES AND RUBBER
DURAL RUBBER CORP.
GOODYEAR TIRE & RUBBER CO.
Hodgman Rubber Co.
United States Rubber Co.
WOOD, J. W., ELASTIC WEB CO.
Whitley Exerciser Co.

TOOLS
American Tool Works Co.
Bass Brothers
BLUM, JULIUS & CO.
Brooks Machine Co.
Browne & Sharpe
Buffum Tool Co.
Cooper Aeroplane Co., The John D.
GREB CO.
HALL-SCOTT MOTOR CAR CO.
HAMMACHER, SCHLEMMER & CO.
LANSING STAMPING & TOOL CO.
Peck, Stowe & Wilcox Co.
Rich Tool Co.
Rogers Works, John M.
Smith & Hemenway
Whitman & Barnes Mfg. Co.

TRUCKS AND TRAILERS
Federal Motor Truck Co.
Four Wheel Drive Auto Co.
Fruehauf Trailer Co.
Nash Motors Co.
Packard Motor Car Co.
Sechler Company, The
Service Motor Truck Co.
White Company, The

TUBING
American Tube Co.
BLUM, JULIUS & CO.
Dewes Co., The A.
Empire Art Metal Co.
Frasse & Co., Peter A.
National Tube Co.
Pennsylvania Flexible Metallic Tubing Co.
STIMPSON, EDWIN B., CO.

TURNBUCKLES
Aero Mfg. & Accessories Co.
Dayton Metal Products Co.
Dillner-Meyer Mfg. Co.
ERIE SPECIALTY CO.
National Aeroplane Co.
New York & Hagerstown Metal Stamping Co.
STANDARD TURNBUCKLE CO.
STEEL PRODUCTS CO.

WHEELS
ACKERMAN WHEEL CO.
Dayton Wire Wheel Co.
Hayes Wheel Co.
Mott Wheel Works
NATIONAL WIRE WHEEL WORKS.
Spranger Wire Wheel Corp.
Watson Wheel & Rim Corp.
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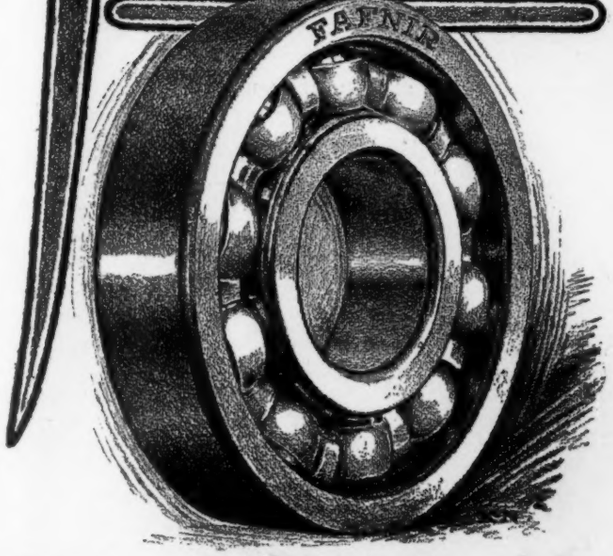

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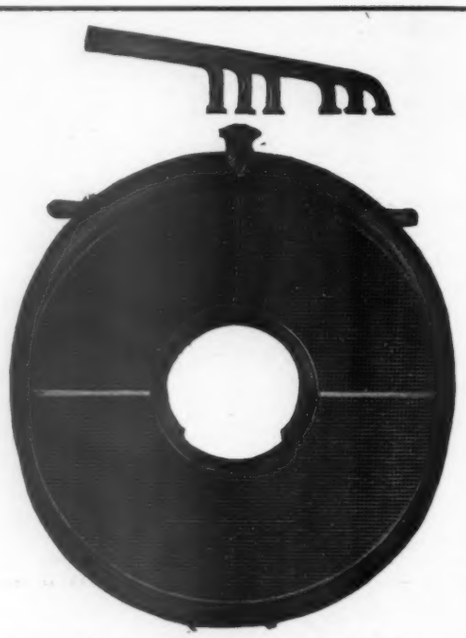

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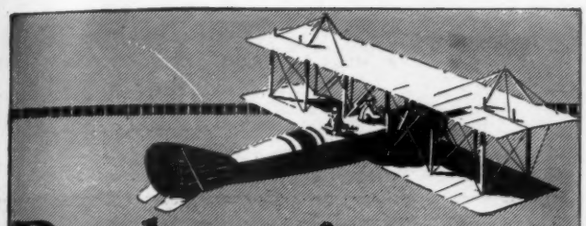

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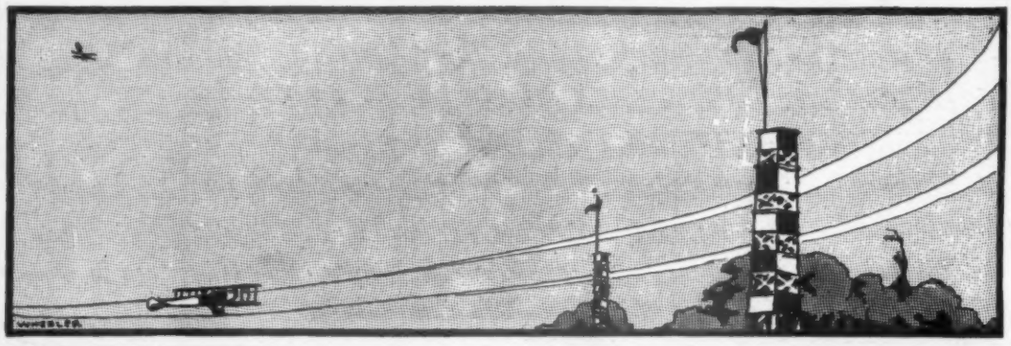

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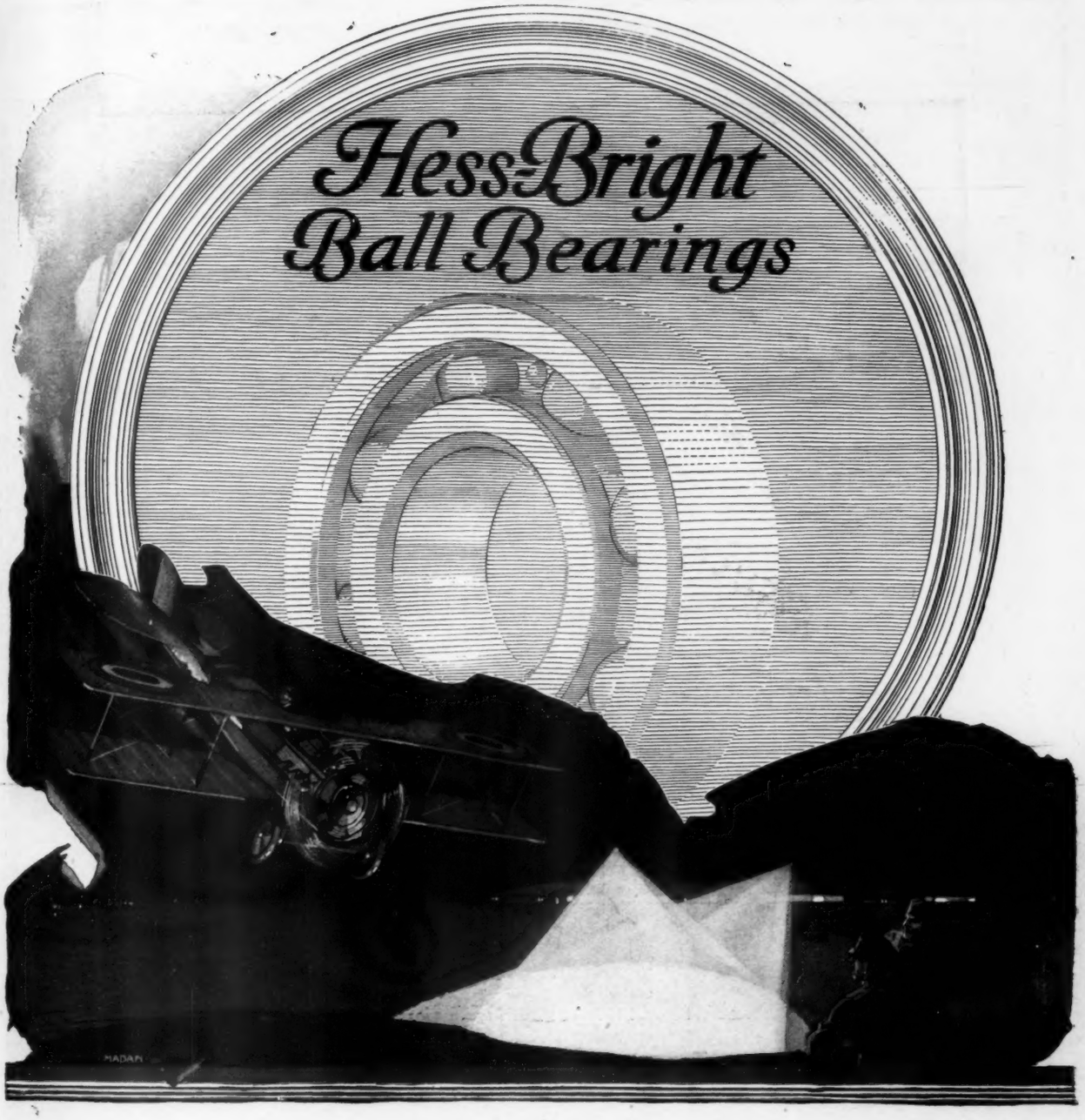

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